UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

PhD program in Doctoral Program in Statistics and Operations Research

Understanding Investor Reaction to Sustainability News in Energy Companies: Fossil vs. Renewable vs. Nuclear, Tone Effects, and COVID-19 Impacts through a Multi-Study Approach using Event Study Methodology.

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Abstract

This thesis contributes to the existing literature confirming empirically and, with a sample never seen before due to its magnitude, that sustainability news moves the stock market, especially in the face of positive fossil energy news, demonstrating a business case for greenwashing.

The doctoral thesis is divided into four chapters. First, the previous literature is analysed through a bibliometric study and an economic impact analysis. This chapter served as an introduction and exploration of the research topic and helped us to define the hypotheses of the doctoral thesis. This first chapter has been presented at XXI Congreso Internacional AECA: Business and society: sustainability and digital transformation.

The second and third chapter respectively analyze the impact on the stock market of all the sustainability news published globally between 2017 and 2019 on the leading European and American energy companies through the event study methodology. The European analysis is published in Applied Economics https://doi.org/10.1080/00036846.2021.2009759, and the American one is published in Environmental Research and Public Health https://doi.org/10.3390/ijerph192315489.

To conclude this thesis, the fourth chapter compares the European and American stock market reaction before and during the pandemic COVID-19. This paper is also published in Sustainability https://doi.org/10.3390/su142315836.

Abstract first chapter

For decades, scientific literature has tried to clarify whether investing in corporate sustainability results in a positive economic return for companies. If so, researchers want to know who the beneficiary is: if it is the investors, the stakeholders or just the environment. The objective of the first chapter is to present a state-of-the-art study about the economic impact of being sustainable. For this, the 200 most-cited peer-reviewed articles about 'Corporate Sustainability Performance' until May 2018 using the Scopus database were analysed. From these 200 papers, a bibliometric study was performed and then, an expert classification with the objective of obtaining a detailed study of how sustainability research has analysed the relation between corporate sustainability and economic performance. The most outstanding conclusion of the expert analysis is that 70% of the companies that introduce sustainability measures have a positive economic impact in their operational or financial results.

Abstract second chapter

The second chapter aims to investigate how the investors of leading European energy companies value sustainability narratives. It uses news from the Global Database of Events, Location, Language, and Tone (GDELT) and analyses the cumulative average abnormal returns (CAAR) and abnormal volatilities (AV), incorporating the event study methodology. A total of 279,546 high-volume news was used, and 4,026 event studies were conducted. The extensive analysis of data and the segmentation of the news by tone, type of energy generation and environmental consequences helps to understand investors' investment decisions. This chapter found that the sustainability narrative significantly impacts shareholder value; however, this narrative's interpretation has no consensus. The sustainability news about these companies moves the stock market upwards for some investors, while others do the contrary. These results are observed by comparing CAAR and AV. The results found by this chapter are crucial for regulators to push forward an effective ecological transition. It should be legislated so that there is a common investors' narrative, discouraging highly polluting investments.

Abstract third chapter

The third investigates how investors of leading United States energy companies value sustainability narratives in news media. Leveraging the Global Database of Events, Language and Tone (GDELT), 207,386 news were extracted, and 4,101 events studies were performed, with 3,393 analyzing cumulative average abnormal returns and 708 analyzing abnormal volatilities. The magnitude of the data analysis and further segmentation of the viral news by tone, type of energy, and environmental consequence help understand investors' investment decisions and reactions. We proved that the sustainability narrative has a significant impact on shareholder value. There is a clear negative bias toward sustainability news. More importantly, positive news about fossil fuels positively impacts the market more than positive renewable energy news. These results provide empirical evidence of greenwashing. There must be a common shareholder's narrative to penalize and reduce incentives for highly polluting investments to push forward an effective ecological transition. Regulatory authorities should develop stricter regulation and incentives to fight against fake sustainability news.

Abstract fourth chapter

The fourth chapter analysed how positive, neutral, and negative sustainability news impacts the share prices of American and European energy companies, focusing on short-term market

reactions. We used the event study methodology to analyse the cumulative average abnormal returns (CAAR). We gathered 2,134 event studies to compare the periods before and during COVID-19 according to the type of energy source (renewable, fossil fuel or nuclear) and news sentiments. We analysed all global and digital news on sustainability from 2017 to 2020 using the GDELT news database as a source of information, which contains 295,093 viral news stories (high-volume news). Our goal was to understand whether or not sustainability narrative has similar effects on shareholder behaviour in both markets and whether the pandemic changed the way investors invest. The results showed notable differences between the American and European market reactions. The American market was much more optimistic, particularly during the pandemic. At the same time, the European market was more negative, showing declines in prices even in the face of positive news about nuclear and renewable energy. Nevertheless, both markets agreed that nuclear power was still on investors' agenda. Finally, fossil fuels were less penalised by investors following negative or neutral news than other types of energy and were equally or more rewarded following positive news. So, it could be concluded that fossil fuel investors were less impacted by negative news about the energy market before and during COVID-19.

Key Words: Event Study methodology; News Analytics; Stock Market; Shareholders Behaviour; GDELT; Big Data; Sentiment Analysis; Expected Return models; Narrative Economics

Resumen

Esta tesis contribuye a la literatura existente confirmando empíricamente y con una muestra nunca vista con anterioridad, por su magnitud, que las noticias de sostenibilidad mueven el mercado de valores, especialmente frente a las noticias positivas sobre energías fósiles, lo que demuestra que existe un caso de negocio para el lavado de cara verde o *greenwashing*.

La tesis doctoral se divide en cuatro capítulos. En primer lugar, se analiza la literatura previa a través de un estudio bibliométrico y posteriormente, un análisis de impacto económico. Este capítulo sirvió como introducción y exploración del tema de investigación y nos ayudó a definir las hipótesis de la tesis doctoral. Este primer capítulo se ha presentado en el XXI Congreso Internacional AECA: Empresa y sociedad: sostenibilidad y transformación digital.

El segundo y tercer capítulo analizan respectivamente el impacto en el mercado de valores ante todas las noticias de sostenibilidad publicadas a nivel mundial entre 2017 y 2019 sobre las principales compañías energéticas europeas y americanas a través de la metodología de estudio de eventos. El análisis europeo está publicado en Applied Economics https://doi.org/10.1080/00036846.2021.2009759, y el estadounidense está publicado en Environmental Research and Public Health, https://doi.org/10.3390/ijerph192315489. Para concluir esta tesis, el cuarto capítulo compara la reacción de los mercados bursátiles europeos y americanos antes y durante la pandemia del COVID-19. Este artículo también está publicado en Sustainability, https://doi.org/10.3390/su142315836.

Resumen primer capitulo

Durante décadas, la literatura científica ha tratado de esclarecer si invertir en sostenibilidad corporativa genera un retorno económico positivo para las empresas. Si es así, los investigadores han querido saber quién es el beneficiario: si son los accionistas, las partes interesadas o simplemente el medio ambiente. El objetivo del primer capítulo es presentar un estudio de estado del arte sobre el impacto económico de ser sostenible. Para ello, se analizaron los 200 artículos revisados por pares más citados sobre 'Desempeño de sostenibilidad corporativa' hasta mayo de 2018 utilizando la base de datos Scopus. A partir de estos 200 trabajos se realizó un estudio bibliométrico y luego una clasificación de expertos con el objetivo de obtener un estudio detallado de cómo la investigación en sustentabilidad ha analizado la relación entre sostentabilidad empresarial y desempeño económico. La conclusión más destacada del análisis de los expertos es que el 70% de las empresas que implantan medidas de sostenibilidad tienen un impacto económico

positivo en sus resultados operativos o financieros.

Resumen segundo capitulo

El segundo capítulo tiene como objetivo investigar cómo los accionistas de las principales empresas energéticas europeas valoran las narrativas de sostenibilidad. Utiliza noticias de la Base de Datos Global de Eventos, Ubicación, Idioma y Tono (GDELT) y analiza los rendimientos anormales promedio acumulados (CAAR) y las volatilidades anormales (AV), a través la metodología de estudio de eventos. Se utilizaron un total de 279.546 noticias y se realizaron 4.026 estudios de eventos. El extenso análisis de datos y la segmentación de las noticias por tono, tipo de generación de energía y consecuencias ambientales ayuda a entender las decisiones de inversión de los accionistas. Este capítulo encontró que la narrativa de sostentabilidad impacta significativamente el valor para los accionistas; sin embargo, la interpretación de esta narrativa no tiene consenso. Las noticias de sostenibilidad de estas empresas mueven al alza la bolsa para algunos accionistas, mientras que otros hacen lo contrario. Estos resultados se observan comparando CAAR y AV. Los resultados encontrados en este capítulo son cruciales para que los reguladores impulsen una transición ecológica efectiva. Debería legislarse para que haya una narrativa común de los accionistas, desincentivando inversiones altamente contaminantes.

Resumen tercer capitulo

El tercer capítulo investiga cómo los accionistas de las principales empresas energéticas de EE. UU. valoran las narrativas de sostenibilidad. Aprovechando la Base de Datos Global de Eventos (GDELT), se extrajeron 207.386 noticias, realizando 7.425 estudios de eventos. La magnitud del análisis y la mayor segmentación de las noticias virales por tono, tipo de energía y consecuencia ambiental ayudan a comprender las decisiones de inversión y la narrativa de los accionistas. El análisis demostró que la narrativa de sostenibilidad tiene un impacto significativo en el valor para los accionistas. Existe un claro sesgo negativo en las noticias de sustentabilidad, impactando negativamente en el mercado. Más importante aún, se identificó que las noticias positivas sobre los combustibles fósiles tienen un impacto mucho más positivo en el mercado que las noticias positivas sobre energía renovable. Estos resultados son evidencia empírica para el caso de negocios de lavado de cara verde. Para que exista una transición ecológica efectiva, se deben conseguir una narrativa común de los accionistas para penalizar y reducir los incentivos para inversiones altamente contaminantes. Estos resultados brindan un objetivo para que los reguladores desarrollen más regulaciones e incentivos para luchar contra las noticias falsas sobre sostenibilidad.

Resumen cuarto capitulo

El cuarto capítulo analiza cómo las noticias de sostenibilidad positivas, neutrales y negativas fluctúan los precios de las acciones de las empresas energéticas estadounidenses y europeas, centrándose en la reacción del mercado a corto plazo. Utilizamos de nuevo la metodología de estudio de eventos para analizar las rentabilidades anormales medias acumuladas (CAAR). Este estudio realizó 2 134 estudios de eventos y comparó períodos pre-COVID-19 y COVID-19 y el tipo de energía: renovables, combustibles fósiles o nuclear.

Utilizamos todas las noticias globales y digitales sobre sustentabilidad desde 2017 hasta 2020 utilizando la base de datos de noticias GDELT como fuente de información, que suman 295,093 noticias.

El objetivo era comprender si la narrativa de sostenibilidad es similar para los accionistas en ambos mercados y si la pandemia ha cambiado la forma en que invierten los accionistas. Los resultados muestran diferencias notables entre las reacciones del mercado estadounidense y europeo a las noticias de sostenibilidad. El mercado estadounidense es mucho más optimista, particularmente durante la pandemia. Al mismo tiempo, el europeo es más negativo, mostrando caídas en su precio incluso ante noticias de tono positivo sobre nuclear y renovables. No obstante, ambos mercados coinciden en que la energía nuclear sigue estando en la agenda de los inversores y que los combustibles fósiles son menos penalizados por los inversores por noticias negativas o neutrales que otras energías y son igual o más recompensados por las positivas. Entonces, se podría concluir que los combustibles fósiles están más permitidos que otros jugadores en el mercado energético antes y durante el COVID-19.

Palabras Clave: Metodología de Estudio de Eventos; Análisis de Noticias; Bolsa de Valores; Comportamiento de los Accionistas; GDELT; Análisis Grandes Datos; Análisis de los Sentimientos; Modelos de Retorno Esperado; Economía Narrativa

Preface

The purpose of this thesis is to examine, from an economic perspective, the incentives that companies must possess in order to be deemed sustainable, or at least appear to be so. The scientific community has reached a consensus on the reality of climate change, and international agreements have been established to limit the global temperature increase to more than 1.5 degrees Celsius (COP25; United Nations Climate Change, 2019). However, the path to sustainability for companies is not clear-cut, as they are faced with conflicts between profitability and environmental responsibilities. Additionally, there is a lack of international, audited legislation regarding the presentation of information on sustainability, and the energy sector remains heavily reliant on fossil fuels and continues to produce increasing levels of CO2 emissions.

Despite this, investments in sustainable financial assets continue to grow. According to the Global Sustainable Investment Review 2018, investments in sustainable assets totalled approximately $31 trillion, representing a 34% increase since 2016. The report also noted that socially responsible investments (SRIs) accounted for between 18% in Japan and 63% in Australia and New Zealand of all professionally managed assets. The academic literature has also reflected this trend, with multiple authors analyzing the exponential growth in SRIs (Pinney et al., 2019; Ruggie and Middleton, 2019; Unruh et al., 2016; Andersson et al., 2016).

Given the ambiguous signals being sent by markets and investors regarding sustainable investments, this thesis aims to understand whether investors of leading energy companies in Europe and the United States take sustainability into account in their investment decisions and if the COVID-19 pandemic has impacted their investment patterns in regard to sustainability. To accomplish this, we analyzed the reactions of energy investors to global sustainability news.

The energy sector was chosen for study as it is central to the economy and strategic in the ongoing transition towards decarbonization. However, fossil fuels remain the primary source of energy, accounting for approximately 70% of European energy production (European Environment Agency, 2020) and 80% of American energy production (Capuano, 2018). Additionally, while investments in renewable energy continue to increase and companies profess to be becoming more sustainable, greenhouse gas emissions continue to rise (Elmalt, Igan and Kirki, 2021).

Furthermore, we selected high-volume sustainability news as a source of information, as the media plays a crucial role in the ESG dialogue and is associated with fluctuations in stock markets (Tetlock, 2007). Scientific research has also demonstrated a direct correlation between ESG news and stock market fluctuations (Capelle-Blanchard and Petit, 2019; Jacobs et al., 2010; Klassen and McLaughlin, 1996; Serafin and Yoon, 2021), particularly in response to negative news (Flammer, 2013; Krüger, 2015).

The research aims to understand investors' reactions to sustainability news from three perspectives:

- Analyzing profitability (Sharma et al., 2021; Maiti, 2020; Muhmad and Muhamad, 2020; Kumar et al. 2016; Friede, Busch, and Bassen, 2015; Ang, 2015) - does the value of investors' shares increase or decrease in response to sustainability news?
- Understanding investors' bias from a Behavioral economics perspective - do investors understand the facts and make logical decisions, or do they amplify negative information (Shelifer and Vishny, 1997; Olsen, 1998; Tetlock, 2007)?
- Utilizing narrative economics to understand whether investors align with sustainability narratives and identifying which narratives become popular (Shiller, 2019).

Finally, I would like to give my acknowledgments:

I have encountered many difficulties throughout the four years that I have dedicated to this project, combining it with my work and from Sweden. However, with the help of my thesis director, tutor and the Department of Statistics and Operations Research staff, it has not been so difficult.

Therefore, my main thanks go to my tutor, Xavier Tort, for his help, words of encouragement, and trust in me. He has made this project go ahead, and it has also been enjoyable and enriching.

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Last but not least, to Laura Vivas, whose help, advice, and understanding have been precious to me.

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List of abbreviations and symbols

CSP: Corporate Sustainability Performance

CSR: Corporate Social Responsibility

SRI: Socially Responsible Investment

CO2: Carbon Dioxide

COP25: UN Climate Change Conference 2019

ESG: Environmental Social and Governance

COVID-19: Coronavirus Disease 2019

GDELT: Global Database of Events, Location, Language, and Tone

CAAR: Cumulative Abnormal Average Returns

AR: Abnormal Return

AV: Abnormal Volatilities

mm: Market Model:

mam: Adjusted Market Model

cpmam: Comparison Period Mean Adjusted Model

Garch: Generalized Autoregressive Conditional Heteroskedasticity

Egarch: Exponential Generalized Autoregressive Conditional Heteroskedasticity

T_{skew}: Skewness adjusted t-test

Glossary

Corporate Sustainability Performance (CSP): Corporate sustainability performance is the ability of a company to meet its economic, social, and environmental responsibilities and goals. It can be evaluated through various metrics like environmental impact, employee engagement and stakeholder relations. A company with strong sustainability performance is better prepared to face long-term challenges in business.

Corporate Social Responsibility (CSR): a company's commitment to operate ethically and contribute to economic development while improving the quality of life of the workforce and their families as well as of the local community and society at large. CSR activities may include implementing sustainable business practices, engaging in fair trade, providing education and job training, and participating in philanthropy and community service. CSR is not only a moral obligation but also a way for companies to build brand value and reputation, attract customers and employees, and create long-term financial benefits.

Socially Responsible Investment (SRI): is an investment strategy that incorporates environmental, social and governance (ESG) criteria into the investment process. This type of investment seeks to achieve financial returns while positively impacting society and the environment. SRI investors consider factors such as a company's labour practices, environmental impact and business ethics when making investment decisions. The goal of SRI is to promote responsible and sustainable business practices while also generating financial returns for investors. It is also known as sustainable investing, green investing, socially conscious investing, and ethical investing.

CO2: or carbon dioxide, is a naturally occurring chemical compound made up of one carbon atom and two oxygen atoms. It is a colourless, odourless gas that is essential to the survival of plants and other organisms. However, in recent times, high levels of CO2 in the atmosphere, mainly as a result of human activities such as burning fossil fuels and deforestation, is causing global warming and climate change. CO2 is considered a greenhouse gas, which means it helps trap heat in the Earth's atmosphere, leading to a warming of the planet. The control of CO2 emissions is critical in order to avoid the most severe consequences of the climate change.

UN Climate Change Conference 2019 (COP25): was a United Nations summit held in Madrid, Spain in December 2019. The conference brought together representatives from governments, businesses, and civil society organizations from around the world to discuss and negotiate actions to address climate change. The main focus of the conference was on the implementation of the Paris Agreement, a global treaty to combat climate change by limiting global warming to well below 2 degrees Celsius and pursuing efforts to limit it to 1.5 degrees Celsius. The COP25 also aimed to accelerate the implementation of the Paris Agreement and increase ambition of countries' climate action to achieve the goal of limiting global warming.

Environmental Social and Governance (ESG): refers to three factors that investors consider when evaluating the sustainability and societal impact of an investment.
Environmental refers to a company's impact on the natural environment, including its carbon footprint and environmental policies.
Social refers to a company's impact on society, including its labor practices, human rights record, and community relations.
Governance refers to a company's leadership, internal controls, and ethical behavior.
ESG analysis helps investors to identify companies that are well-managed, financially stable, and have a positive impact on society and the environment. ESG criteria are increasingly being used by investors as a way to measure a company's long-term viability and potential for growth.
COVID-19: is a highly infectious and potentially severe respiratory illness caused by the SARS-CoV-2 virus. It was first identified in Wuhan, China in December 2019 and has since spread rapidly to become a global pandemic. Symptoms of COVID-19 include fever, cough, shortness of breath, and difficulty breathing. The virus primarily spreads through respiratory droplets when an infected person talks, coughs, or sneezes. People who have been in close contact with an infected person or have traveled to areas with ongoing transmission are at higher risk of infection. The virus primarily attacks the respiratory system, but also can cause severe illness and death, particularly in older adults and those with underlying health conditions. To prevent the spread of the virus, public health authorities have recommended measures such as social distancing, wearing masks and frequent hand washing.
Narrative Economics: Narrative economics is a field that examines the role that stories, and narratives play in shaping economic decision-making and outcomes. It posits that the stories that people hear and tell can influence their beliefs, expectations, and behaviors, and that these in turn can affect economic outcomes. It also highlights the importance of communication in shaping how people interpret and respond to economic information.
Big Data: Big data refers to extremely large and complex data sets that are difficult to process and analyze using traditional data processing methods. These data sets come from a variety of sources, such as social media, e-commerce, sensors, and other digital devices, and can include structured, semi-structured, and unstructured data. The volume, velocity, and variety of big data requires specialized technology, such as distributed computing and machine learning, to process and extract insights from it. The goal of big data is to discover hidden patterns, correlations, and insights that can help organizations make better decisions and improve their operations.
News analytics: is the use of computational techniques to analyze and understand the content, sentiment, and meaning of news articles and other text-based data sources. It is used to extract insights

and information, track the spread of news, identify key topics and trends, monitor tone and sentiment of news coverage, and inform investment and business decisions.

Shareholder behaviour: Shareholder behavior refers to the actions and decision making of individuals or entities that own shares in a company. This can include buying and selling shares, holding shares for a long-term or short-term period, and participating in corporate governance activities such as voting on matters related to the company's operations. It is influenced by factors such as market conditions, company performance and individual preferences. Understanding shareholder behavior can provide insights into the sentiment towards a company.

Sentiment analysis: is the process of using computational methods to determine the emotional tone of text. It can be used to analyze social media posts, news articles, and other forms of text data to understand the attitudes, opinions, and emotions of the authors. Sentiment analysis algorithms can be based on rule-based, statistical, or machine learning techniques. The outputs of sentiment analysis can be in the form of a binary (positive or negative) or a multi-class sentiment classification. Sentiment analysis is widely used in areas such as marketing, politics, and social media monitoring.

GDELT: is a database that tracks and analyzes news articles, social media posts, and other forms of media content from around the world in real-time. The database uses natural language processing and machine learning algorithms to extract and analyze data on events, actors, and sentiments from millions of news sources in over 100 languages. GDELT provides a wide range of data and analytics such as sentiment analysis, tone, media coverage, and the relationships between actors and events. It also provides a platform for data visualization and exploration, enabling researchers and analysts to gain insights into global events and trends. GDELT is widely used in various fields such as media, political science, and international relations for monitoring and analyzing global events, social movements, and public opinion.

Event study methodology: vent study methodology is a statistical method used to analyze the impact of a specific event on the price or returns of a security or market index.

Event study methodology is widely used in finance and economics to study the impact of various events on securities and markets, and it can provide valuable insights into market reactions and investor perceptions.

Cumulative Abnormal Average Returns (CAAR): is a statistical measure used in finance and economics to evaluate the performance of a company or security relative to the overall market. It is used to measure the abnormal return of an event, such as an announcement or release of financial results, on the returns of a security or portfolio. The CAAR is calculated by comparing the average returns of a security or portfolio over a certain period of time before and after an event, and then cumulating the difference. A positive CAAR value indicates that the security or portfolio outperformed the market, while a negative value indicates underperformance. The CAAR is

commonly used in event studies, which are used to evaluate the market's response to a specific event or announcement.

Abnormal Return (AR): is a statistical measure used in finance and economics to evaluate the performance of a company or security relative to the overall market. It is used to measure the returns of a security or portfolio over a certain period of time before and after an event, such as an announcement or release of financial results, that are not explained by the overall market performance. It is calculated by subtracting the expected return of the security or portfolio based on the market performance from the actual return over the given period. A positive AR value indicates that the security or portfolio outperformed the market, while a negative value indicates underperformance. Abnormal returns are commonly used in event studies to evaluate the market's response to a specific event or announcement.

Abnormal Volatilities (AV): refers to the deviation of the volatility of a security's returns from the normal level of volatility that would be expected based on market conditions or historical trends.

Expected Return models: In event study methodology, expected return models are used to estimate what a security's return would be in the absence of an event. They are used to calculate abnormal returns, which are the difference between actual returns and expected returns. Commonly used models include market model, historical average, and time-series model. These models are used to measure the impact of events such as earnings announcements on a security's return.

1. Introduction

Awareness of climate change and its causes has increased exponentially in recent years (Grimmer and Bingham, 2013; Qader and Zainuddin, 2011). Mainly since the Paris agreement and even more notably the last two years coinciding with the activist Greta Thunberg's appearance and their school strikes on Fridays, 'Fridays for future,' that led to the most significant mobilizations in the history of climate change in 2019.

This new climate awareness is changing the population's consumption patterns that increase their understanding of the measures they must take to mitigate their ecological footprint, such as energy production, waste management, dietary change, and new consumption patterns, among others (Ackerman, 2000; Akompab et al., 2013; Von Borgstede, Andersson, and Johnsson, 2013; Korkala, Hugg, and Jaakkola, 2014; Soret et al., 2014; Lee et al., 2015; Kabisch et al. ,2016; Adamiak et al., 2016; Muralidharan, Rejón-Guardia, and Xue, 2016).

1.1. Corporate Sustainability Performance

Climate awareness is also changing investment patterns, the interest in knowing whether companies with high corporate sustainability performance (CSP) generate higher financial returns than business as usual has not stopped growing, both in terms of academia and financial markets (Cornell and Damodaran, 2020; de Matos, 2020; Pinney et al., 2019; Ruggie and Middleton, 2019; Sikacz 2017; Zainuldin and Lui, 2021).

1.2. Corporate Social Responsibility

Investors, stakeholders, and researchers have different options to comprehend and value the commitment of the company to its environment: news media, inclusion in sustainability index, audits carried by independent experts and the information provided by the company through corporate social responsibility (CSR) reports (Gray et al., 2001; Kolk, 2005).

Today, CSR has risen as a critical factor in making business decisions (Cochran, 2007). Most of the companies are required by their stakeholders to continue their activity with corporate responsibility, that is, respecting the environment and human rights (Stubbs and Cocklin, 2007; Agnolucci and Arvanitopalos, 2019; Shahbaz et al., 2020). The raised interest of large corporations regarding social responsibility is visible in the increasing number of CSR reports (Campbell, 2004). According to Russell 1000 Index Sustainability Reports 2019, 90% of the companies on the S&P 500 Index published a CSR report in 2019.

1.3. Socially Responsible Investments

Some indexes, such as the Dow Jones Sustainability, STOXX, Ethibel Excellence, Morningstar Socially Responsible Investment Index, among others, are indicators of how investors evaluate social responsibility and how these actions return on creating business value (Barnea and Rubin 2010; Nakai

et al., 2012; Webb, 2005). These indexes were designed to guide investors interested in Socially Responsible Investments (SRIs), to discover companies committed to sustainability. Of course, the SRI does not intend that companies neglect their risk objectives and financial profitability. However, it also incorporates environmental, social and governance issues in investment analysis and asset selection.

Companies are raising their interest in being listed as socially responsible businesses and becoming part of ethical stock indexes, among other reasons because part of these indexes attracts capital from institutional investors. These investors are increasingly becoming aware that proper management of the social and environmental concerns of the company influences the value of the company in the medium and long term (Aouadi and Marsat, 2016; Oberndorfer et al., 2013; Flammer, 2013; Webb 2005).

Therefore, it can be said climate awareness and SRI are changing investment patterns. For example, Laurance D. Fink, the founder and chief executive of Blackrock, the world's largest investment fund managing $7 trillion, announced in 2020 that sustainability will be the core of its investments and that his fund will be disinvesting in fossil energy companies henceforth (New York Times, 2020). However, Blackrock is by no means the first investment fund that reflects the growing environmental awareness of the investors. In fact, in December 2019, 631 investors handling $37 trillion signed a letter urging governments to curb climate change and meet the objectives of the Paris agreement. However, these significant investment funds have also historically been the primary sources of investment for fossil fuel companies.

According to the Global Sustainable Investment Review 2018, investments in sustainable assets were around $31 trillion, an increase of 34% since 2016. They also highlighted that SRIs represent between 18% in Japan and 63% in Australia and New Zealand of all professionally managed assets. The scientific literature has also echoed this trend, and many authors have analysed the exponential increase in SRIs (Pinney et al., 2019; Ruggie and Middleton, 2019; Unruh et al., 2016; Andersson et al., 2016).

Due to the significant growth of CSR reports and SRIs, the scientific community is investigating how the market reacts in terms of economic profitability to the socially responsible attitude of the companies. As mentioned above, this kind of investment is dragging an increasing number of investors; however, they are, nevertheless, a minority compared to the number of conventional investors, defining them as those who only seek profit maximisation. Therefore, researchers want to understand if, for these conventional investors that drive most of the market, CSP is a fundamental factor and how they can consider it: positively, negatively, or neutrally.

That is why there is a clear incentive for companies to be, or at least appear sustainable, especially in an era where the amount of available information has grown exponentially and has been proven by

numerous studies that media coverage has a very significant impact on the financial markets (Tetlock et al., 2007; Robertson, Geva, and Wolff, 2006; Doukas, Kim, and Pantzalis ,2005; Apergis and Miller, 2006) and also favored by new technologies that allow the automatic downloading of news, aggregation, and categorization (Li et al., 2017; Ammann, Frey, and Verhofen, 2014; Carretta et al., 2011; Mitra and Mitra ,2011).

1.4. Fossil Fuel energies and Investments

However, fossil energies remain the primary energy source, representing almost 70% of energy production in Europe, the European Environment Agency (2020). While it is true that the production of renewable energy increases each year, in Europe, it has doubled, from 7.2% to 14.8% in 2017, European Environment Agency (2020), the leading energy companies are dependent on fossil energies and, almost all of them are in the stock market. So, the stock market's interest is still strongly linked to fossil energies as they continue to have the dominant energy position.

The same context is found in the US, the world's most active stock market, where the investments in ESG are lower than in Europe. In 2018, the US had $ 11.9 trillion invested in sustainable assets, while in Europe, this figure amounted to $ 14 trillion (Alliance, G. S. I., 2018). Nevertheless, the American investment in ESG represents only 25% of the total while the European represents 49% (Alliance, G. S. I., 2018). This low American percentage is due to the still significant dependence on fossil fuels in the American market; 80% of the energy they consume comes from oil, coal, and natural gas, all of which are fossil fuels (Capuano, 2018). Another influential factor has been US regulation on sustainability, which has moved into disinterest and even discouraging positions under the Trump administration.

However, this trend is changing with the new administration, the return to the Paris agreement and the increasing presence of ESG companies in the stock market. More than eight in ten US investors are interested in sustainable investments, and half of them have investments in at least one sustainable asset (Institute for sustainable investment, 2019).

However, even though there are more companies and investors than ever claiming to be sustainable, CO2 emissions have not stopped growing (Elmalt, Igan and Kirki, 2021), indicating first that the sustainability narrative is not aligned and second pointing to clear incentives for the companies' greenwashing.

1.5. Greenwashing

Greenwashing refers to the different forms of misleading information that companies transmit to their stakeholders (investors, suppliers, clients, social environment, etc.) to sell the idea of being an environmentally responsible company. Selective information dissemination wants to cover up negative environmental actions that are taking place.

In the last decade, the number of CSR reports has not stopped growing due to greater demand from stakeholders for information and transparency (Tang and Demeritt, 2018). However, CSR reports are not mandatory in important markets like the United States. Moreover, in Europe, even though there is an obligation to submit CSR reports for listed companies, but there is neither audit nor guidelines. This translates into more CSR reports for companies that carry out environmental activities as an indicator of the signalling theory (Karaman, Kilic and Uyar, 2020), meaning sending signals of being pro-environment to their stakeholders.

However, as was mentioned before, CO2 emissions have not stopped growing, even as companies claim to be more sustainable than ever (Elmalt, Igan and Kirki, 2021), showing evidence of greenwashing.

In the academic world, interest in greenwashing has not stopped growing in the last decade either, since, as Lyon and Montgomery (2015) affirm, it proposes interesting and multidisciplinary challenges.

In the field of finance, researchers want to know why companies do greenwash, agreeing that it is in search of legitimacy, since the greater the environmental reputation, the less impact on future scandals (Aouadi and Marsat, 2016; Flammer, 2013; Oberndorfer et al., 2013). Other researchers point out that engaging symbolically in some environmental action reinforces its values and signals commitment to shareholders (Connely et al., 2011; Lyon and Maxwell, 2011). At the same time, others point to a stunt to outperform the competition (Parguel, Benoit-Moreau and Larceneux, 2011).

2. Motivation

The motivation for this thesis is to understand, from an economic point of view, what incentives companies must have to be sustainable or at least appear so.

It is known that there is scientific consensus about climate change, and there are also international commitments to limit the increase in temperature to more than 1.5 degrees Celsius (COP25; United Nations Climate Change, 2019). However, the narrative for companies is not obvious, and they are facing contradictions between profitability and environmental commitments. Moreover, there is no international and audited legislation on how to present information on sustainability; energy production continues to be highly linked to fossil fuels, and CO2 emissions do not stop growing. So, with this context, several questions arose in the development of this research:

• Are sustainable companies better valued by investors than unsustainable companies?

• Are investors able to distinguish greenwashing information from facts?

• Is it profitable as a company to invest in a non-real sustainable narrative (greenwashing)?

• Are companies more vulnerable to losses if negative sustainability information is published about them?

• And is profitable for them when good news is published?
• Do investors rate news about investments in highly CO2-emitting industries negatively?
• Or do investors continue to invest in highly polluting companies because they offer high returns?
• Investments in ESG do not stop growing, and neither CO2 emissions. Does this mean that the stock markets encourage greenwashing?

The first chapter of this thesis was carried out to solve all these questions and propose concise objectives for this doctoral thesis. This chapter combines a bibliometric study and an analysis of the previous literature. The most relevant articles on "Corporate Sustainable performance" are analysed to determine an economic impact linked to sustainability.

3. Objectives

After analyzing the 200 most cited articles on "Corporate Sustainability Performance", it was discovered that the financial accounts were the most affected by sustainability. The companies benefit with profits when the information on sustainability is positive (corporate governance reports, news, announcements, among others) and with losses when it is negative. But, as we saw before, the economy is still highly dependent on fossil fuels and companies are embracing greenwashing more than ever.

Due to the ambiguous signals that the markets and investors are sending about sustainable investments, this thesis wanted to understand whether the investors of the leading energy companies in Europe and the USA consider sustainability in their investment decisions and whether the COVID-19 pandemic has changed their investment patterns towards sustainability.

To do this, we analyzed how the energy investors react to all digital global news on sustainability.

The energy sector was chosen because it is the most strategic and central to the economy during the current ecological transitions towards decarbonisation. However, fossil fuels remain the primary energy source, representing almost 70% of European energy pro-duction (European Environment Agency, 2020) and 80% of American energy production (Capuano, 2018). Furthermore, while investments in renewable energy continue to grow and companies claim to be increasingly sustainable, greenhouse gases continue to rise (Elmalt, Igan and Kirki, 2021).

Also, we selected high-volume sustainability news as a source of information since the media plays a crucial role in the ESG dialogue and is associated with fluctuations in stock markets (Tetlock, 2007). Furthermore, more and more scientific research has empirically demonstrated that ESG news directly impacts stock markets (Capelle-Blanchard and Petit, 2019; Jacobs et al., 2010; Klassen and McLaughlin, 1996; Serafin and Yoon, 2021). Especially negative news (Flammer, 2013; Krüger, 2015).

The research aims to understand investors' reactions to sustainability news from three lines of research.

- Analysing profitability (Sharma et al., 2021; Maiti, 2020; Muhmad and Muhamad, 2020; Kumar et al. 2016; Friede, Busch, and Bassen, 2015; Ang, 2015) do the value of investors' shares gains or loses value when sustainability news is published.
- Understanding investors' bias, from behavioural economics, can investors understand the facts and act logically? Alternatively, do they amplify negative information (Shelifer and Vishny, 1997; Olsen ,1998; Tetlock, 2007).
- Using narrative economics to understand whether investors agree with the sustainability narratives and discover which ones go viral (Shiller, 2019).

This thesis purpose is to analyze the impact on the stock market capitalization of high-volume news (news with a high number of readings) all over the word about sustainability for leading European and US energy companies (Thomson Reuters Top 100 Global Energy Leaders Ranking, 2019). The intention is to capture the average investor sentiment about sustainability narratives and the consequences on the investors' value. To achieve that, we have analysed all news published digitally worldwide from January 2017 to December 2020 that mention in their articles the companies of the sample and a combination of keywords about sustainability and type of energy generation, and then, through the event study methodology linked it to the stock market data. So, we analyzed how investors value sustainability, the cost for companies of getting good and bad press, and whether greenwashing is profitable. We also compared periods before COVID-19 and during the pandemic to witness if investors change their sustainable priorities in the face of uncertainty.

We have used the open-source databases Global Database of Events, Location, Language, and Tone (GDELT) for the news and Yahoo Finance for the market data to carry out this study.

To understand the research's magnitude, it should be noted that GDELT is the largest and more comprehensive global news database worldwide. It is continuously updated and analysed more than 88 million articles a year in over 100 languages; as Kwak and An (2016) describe it, it is a tale of the world. I downloaded from GDELT 486.932 news containing information about the companies analysed and the sustainability keywords.

To measure the economic impact of sustainability high-volume news, several events studies have been conducted, 14.850 to be exact, with five different expected return models. The event study methodology analyzes whether a series of events have an impact on a variable of interest. In this case, the shares' returns and volatilities by analyzing the behaviour of their historical prices and performances.

The magnitude of the analysis and further segmentation of the viral news by tone, type of energy, and environmental consequence help understand investors' investment decisions and narrative.

4. Contributions

The potential contributions of this paper are numerous. The first is its magnitude. The number of news analysed allow us to report robust results. To the best of my knowledge, no study has been published investigating the effects on the capitalization of the stock market of all the news published worldwide on sustainability segmented by tone and type of energy generation. Previous studies have analysed the effects of sustainability or ESG news only in some media or with more restricted concepts and hand-collected news, making their results much less robust. In addition, by analyzing periods before and during the COVID-19 pandemic, we can explore whether the investors' priorities have changed regarding sustainability as they faced high uncertainty.

Second, the extensive analysis of data thanks to databases such as GDELT and the segmentation of news by tone and type of energy generation allow us to reach a level of understanding of the investors' investment decisions much more detailed. This fact can benefit future researchers and executives of large companies to make data-driven decisions on their business. As Grewal, Hauptmann, and Serafein, (2020) confirm, '…researchers have spent little effort to measure corporate sustainability performance… we view this space as the single biggest opportunity for researchers to advance the field.'

Likewise, it is worth highlighting the event study's robustness as we launched a competition of five different expected return models, only accepting statistically significant results if at least three of the five models conclude that.

Finally, and no less important, the value of the results obtained must be stressed. This research provides an understanding of the investor's bias about sustainability and their investment patterns in this regard unpublished so far. Energy companies whose historical business model rely on fossil fuels are facing a complicated situation. They are losing value on their stock market whenever news about climate change is published. The same happens when news about alternative energy models with a less ecological footprint. However, there is an increase in the price of its shares when positive news about fossil fuel companies and their role in curbing climate change is published. This result seems to indicate that Greenwashing is profitable because, to date, none of these companies has invested significantly in a change of their business model, with fossil fuels being their primary source of income.

5. Literature review

5.1. News and the stock market

The media's role in financial markets has been investigated for decades, both academically and in

business.

Thanks to globalization, the information published by the media have worldwide coverage, playing an essential role in fluctuations in stock market prices (Fang and Peress 2009; Da, Engelberg, and Gao, 2009; Barber, Odean, and Zhu, 2009; Tetlock, 2007; Oberlechner and Hocking, 2004). This phenomenon has been consolidated thanks to new technologies that allow the download, aggregation, and categorization of news in real-time (Li et al. 2017; Ammann et al., 2014; Carretta et al., 2011; Mitra and Mitra, 2011).

The information is more affordable than ever, and news about companies and the stock market can be easily acquired (Tyrén, Nilsson, and Jansson, 2019). The media serve as an intermediary provider of information between companies and investors and can shape the investor's expectations (Tetlock, 2014).

Behavioural finance studies argue that investors are affected by their cognitive bias being unable to assimilate all information and act rationally, overreacting to negative news (Shelifer and Vishny, 1997; Olsen, 1998; Tetlock, 2007).

Other researchers impute market fluctuations on companies' visibility and media coverage, not on the information per se (McCombs and Shaw, 1972; Carroll and McCombs, 2003; Tetlock, 2007; Barber and Odean ,2008; Lehavy and Sloan, 2008; Bushee and Miller, 2012).

Chan (2003), Li (2006), and Tetlock (2007) found that companies whose news was negative reported lower earnings. Along the same lines, other researchers have analysed how the press increasingly uses more emotional language to attract more attention, which affects the market to a greater extent (Lewis, Williams, and Franklin, 2008; Vettehen et al., 2010). The scientific literature also collects research that suggests that the market is a mirror of the news rather than a variable and that it is the news that reacts to the market and not the other way around (Oberlechner and Hocking, 2009; Scheufele, Haas, and Brosius, 2011; Thompson, 2013; Strauß, Vliegenthart, and Verhoeven, 2016).

Finally, it is worth to highlight the finding of Shiller (2019). This Nobel laureate argues that the stories people tell can expand like a pandemic and effect and cause significant economic events like movement on the stock markets.

5.2. Sustainability and the stock market

The scientific community had investigated how investors value the efforts of companies to be more sustainable since the 1970s when they considered it purely an expense that hurt shareholders' wealth (e.g., Friedman, 1970; Clotfelter, 1985; Navarro, 1988; Aupperle, Carroll, and Hatfield, 1985; Marcus, 1989; Teoh, Welch, and Wazzan, 1999; Wright and Ferris, 1997).

This argument has been left behind, and as previously analysed, SRIs are attracting more and more capital. Although SRIs remain a minority compared to traditional investments, their growth does not

cease, and announcements such as that of the Black Rock investment fund to abandon fossil fuels investments validate this. Therefore, research in this field wants to know if sustainability is an essential factor for investors in addressing an investment. Several studies, like this one, used the methodology of event studies to measure the connection between environmental measures and financial performance. The difference is that the sample size of these investigations is minor than the one in this dissertation and that I analysed information provided by the media, not the companies themselves. Many of these studies have inferred that the stock market inevitably reacts to positive ecological news, reports, social media, and negative otherwise. The first group of researchers focused on examining the result on the stock price on negative environmental communication, observing a negative impact (Blacconiere and Patten, 1994; Hamilton, 1995; Klassen and McLaughlin, 1996; Konar and Cohen, 1997; Khanna, Quimio, and Bojilova, 1998; Dasgupta, Laplane, and Mamingi, 2001; Grand and D'Elia, 2005; Gupta and Goldar, 2005). This relationship has been noted recently in disasters like the BP Gulf of Mexico (2010) and the nuclear accident at the Fukushima plant in Japan with Tokyo Electric Power Company (2011). The second group of studies has focused on the study of the market reaction to positive environmental communications: Wingender and Woodroof (1997), Yamashita, Sen, and Roberts (1999), Filbeck and Gorman (2004), and Nagayama and Takeda (2006) discovering positives returns.

Some investigations analyze the importance of sustainability in financial returns. One of the most recent is from the Center of Sustainability and Excellence. It detects an apparent correlation between sustainability and financial results in North America. They find that 75% of companies with Sustainability Reports and high ESG (Environmental, social, and corporate governance) ratings reported better financial results than the previous years (Sustainability Reporting Trends in North America, 2018-2019).

Yin et al. (2019) showed positive relationships between the dissemination of environmental information and profitability for companies that substantively address sustainability and those that symbolically. The profitability of companies with symbolic dissemination style is greater than that of the substantive dissemination style.

Another critical research on the question is from Eccles, Ioannou, and Serafeim, (2014). They investigated 180 US companies for 18 years, finding that through the years of study, 'High Sustainability companies' outperformed 'Low Sustainability companies' both in the stock market as well as accounting performance.

In the same direction, identifying positives relations between CSR and Sustainability, it can be read Orlitzky, Schmidt, and Rynes, (2003), Margolis and Walsh, (2003), Maignan, Ferrell, and Ferrell (2005), Marom (2006), Wu and Shen (2013), Van Beurden and Gössling (2008), Abu Bakar and Ameer (2011), and Oeyono, Samy, and Bampton,(2011) amongst others.

5.3. GDELT and the stock market

Most of the research that uses GDELT as a predictive variable is in political science, and its results are hardly exportable to financial markets (Elshendy et al., 2018).

There is limited scientific literature that uses the GDELT news database to analyze the relationship between the information offered by GDELT and the financial markets highlighting, Jakel (2019) that used GDELT to measure the cross-correlation between average media sentiment and closing stock price for Facebook, Apple, Amazon, Alphabet and Tesla. He found that Alphabet was the only company with a strong cross-correlation of average daily media sentiment. Fallahi (2017) also used GDELT to investigate the worthiness of information derived from GDELT in improving the accuracy of stock market trend predictions. His results show that using information from GDELT has a direct positive impact on improving the stock market prediction accuracy. Elshendy et al. (2018) show that social parameters extracted from GDELT, Twitter, Wikipedia and Google Trends have a remarkably high correlation with the oil price movement. Moreover, finally, Memari (2017) investigate the accuracy of predicting the unseen prices of the Down Jones Industrial Average using information form GDELT. His results show that using Ensemble methods has a positive impact on improving prediction accuracy. Alamro, McCarren and Amal Al-Rasheed (2019) deployed multiple multivariate models to predict the daily index of the Saudi stock market using GDELT and its tone segmentation, finding a very accurate forecast. Shen et al. (2022) found, using tone scores and media coverages from GDELT, that media sentiment has significant predictive power for Chinese stock market returns and volatilities. And lastly, Alonso, Gadi and Sicilia (2022) introduced CryptoGDelt2022, a publicly available cryptocurrency corpus analysing a period from the 31st of March 2021 to the 30th of April 2022 and proving that GDELT is less positively biased than news selected from cryptocurrency-specialised websites. As a result, they concluded that GDELT is the right source for cryptocurrency news.

Finally, scientific literature has analysed through GDELT the content of CSR and sustainability news by analysing texts and how the information is related.

Azhar et al. (2019) analysed the CSR news content of Singapore-listed companies demonstrating that the media can be an indicator to assess the CSR prominence of companies and that the use of GDELT as a data source offers an alternative automated and scalable. On the other hand, Gergely et al. (2021) propose a tool to discover, analyse and monitor terms related to sustainable development. Furthermore, they showed how GDELT could help the media explore and interrelate the news geographically and thermally.

As can be seen from the existing scientific literature, GDELT is a good tool for forecasting, connecting, and analysing sentiment bias in the news.

This research contributes to the existing literature with a detailed analysis of how energy companies' sustainability news impacts the stock market using the event study methodology. To our knowledge, no previous studies have performed event studies with news from GDELT or analysed the energy sector. Thanks to the different segmentations studied (type of energy, environmental consequences, period, different geographies, and tone of the news), it is possible to identify what, when and where the news that impacts the most on the investors came from.

Moreover, analysing the energy investors' reaction gives a unique perspective on their sustainability narrative since the energy companies have the money and the capacity to advance or not towards an ecological transition with a lack of adequate legislation.

5.4. Sustainability during the pandemic COVID-19

The scientific literature has also analysed how the COVID-19 pandemic has influenced the stock market returns of ESG factors. And again, there is not an apparent unanimity among the studies on whether a higher ESG index prevents the potential losses associated with COVID-19.

On the one hand, some studies proved that companies that bet on Environmental and Governance factors financially outperformed those with a lower ESG index (Engelhardt et al., 2021; Garel and Petit-Romec, 2021; Gregory, 2022; Huang et al., 2020; Rubbaniy et al., 2021). However, on the other hand, others argue that having a higher ESG index does not prevent financial losses during COVID-19 (Demers et al., 2021; Folger-Laronde et al., 2020; Huang et al ., 2021; Loof, 2021). And lastly, some found that shareholders during the pandemic preferred low ESG funds (Demers et al., 2021; Ferrari and Natoli, 2020).

The COVID-19 pandemic also hit the electricity market as electricity consumption fell to record levels caused of the cessation of economic activity and lockdowns (Kanda and Kivimaa, 2020). Boldeanu, Clemnete-Almendros and Tache (2022) analysed European electricity utilities and their stock Price response to COVID-19. They confirmed negative impacts on the whole industry and exceptionally high on renewable energies.

6. Hypothesis

As I have already analysed in the previous sections, extensive scientific literature demonstrates that the stock market collects information from the press. Traders and other market participants consume information in a massive and fast way, continually reviewing and acting on their investment portfolio (Mitra and Mitra, 2011).

Tetlock (2007) also confirms that the stock market reacts more strongly to negative news than to positive news and taking into consideration the composition of the thesis sample where most of the companies are linked to fossil fuels, we expect, in terms of returns, a decline in the share price of the companies in our sample when negative news about the fossil fuels industry is published and,

conversely, an increase in their share price when the news is positive. The hypothesis read as follow:
H1a: Negative high-volume news from GDELT about sustainability and fossil fuels energies has a negative effect on stock performance in terms of returns for the European and US companies included in the Thomson Reuters Top 100 Global Energy Leaders Ranking 2019.
H1b: Positive high-volume news from GDELT about sustainability and fossil fuels energies has a positive effect on stock performance in terms of returns for the European and US companies included in the Thomson Reuters Top 100 Global Energy Leaders Ranking 2019.
In terms of volatility, being an absolute value, does not distinguish between rises and falls in the share price. Still, we expect significant volatility in the face of news about sustainability and fossil companies, in both tones, negative and positive, but more significantly with the negative ones, since these have a more significant impact on the stock market (Tetlock, 2007). The hypothesis read as follow:
H2a: Negative high-volume news from GDELT about sustainability and fossil fuels energies has a significant effect on stock performance in terms of volatility for the European companies included in the Thomson Reuters Top 100 Global Energy Leaders Ranking 2019.
H2b: Positive high-volume news from GDELT about sustainability and fossil fuels energies has a significant effect on stock performance in terms of volatility for the European companies included in the Thomson Reuters Top 100 Global Energy Leaders Ranking 2019.
Contrarily, news from rival companies can affect the investment decisions of traders. Firms are continually paying attention to all movements and actions that rival companies perform to respond appropriately (Schumpeter, 1934). A central premise in the dynamics of competition is that being aware of and reacting to rival companies' actions gives a competitive advantage (Young, Smith, and Grimm 1996; Grimm, Lee, and Smith 2006). As Porter (1980) notes, competitive exchanges are generally a zero-sum game on the overall market, where one firm's gains come at the expense of the losses of the rival firm.
Therefore, and applying the perspective of competitive dynamics, the second hypotheses focus on firms' reactions to environmental news of fossil fuels rival energy firms, renewables and nuclear.
In terms of returns, stock prices of the companies in our sample (highly linked to the fossil industry) are expected to decline when positive news on renewable and nuclear energy is published. Since what benefits the competition harms them. Conversely, negative news should cause a positive reaction with an increase in its price on the stock market. So, the hypothesis read as follow:
H1c: Negative high-volume news from GDELT about sustainability and non-fossil fuels energies has a positive effect on stock performance in terms of returns for the European companies included in the Thomson Reuters Top 100 Global Energy Leaders Ranking 2019.

H1d: Positive high-volume news from GDELT about sustainability and non-fossil fuels energies has a negative effect on stock performance in terms of returns for the European companies included in the Thomson Reuters Top 100 Global Energy Leaders Ranking 2019.

Finally, In terms of volatilities, as they are absolute values, again statistically significant results are expected both for news with a positive and negative tone:

H2c: Negative high-volume news from GDELT about sustainability and non-fossil fuels energies has a significant effect on stock performance in terms of volatility for the European companies included in the Thomson Reuters Top 100 Global Energy Leaders Ranking 2019.

H2d: Positive high-volume news from GDELT about sustainability and non-fossil fuels energies has a significant effect on stock performance in terms of volatility for the European companies included in the Thomson Reuters Top 100 Global Energy Leaders Ranking 2019.

7. Methods

This section describes the research methods used in chapter two and three, that are the core of this thesis—first, the Sample selection section. Second, in the News Analysis Methodology Section, we will explain how the high-volume news, are identified. Third, the event study methodology will be discussed, which is the methodology we used to identify the news's impact on the stock market, and the expected return models and the significance tests.

7.1. Sample selection

The sample of this chapter contains all the high-volume news published digitally worldwide, and that mentions in its articles the leading European and US Companies in the energy sector and a combination of keywords related to energy and sustainability, as displayed in Table 1, for example: 'Acea SP' + 'gas' + 'nitrogen oxides.' The analysis period is from January 2017 to December 2020.

The databases that used are the following:

For the companies: The European and US companies included in the Thomson Reuters Top 100 Global Energy Leaders Ranking 2019.

For the news: GDELT (The Global Database of Events, Language, and Tone).

For financial data: Yahoo Finance.

Table 1, Data dictionary and Data Bases

Europe Companies*	USA companies*	Energy keywords	Sustainability Keywords
Acea Sp	Anadarko	Gas	Nitrogen
AkerSolutions	Marathon oil corp	Fossil Fuels	Phosphorus
CairnIndia	Avangrid	Renewables	Carbon dioxide
DCC	Chevron corp	Nuclear	CO2
EON SE	CMS Energy	Coal	Methane

EDF	ConocoPhillips	Solar	Ozone
Enagas	ExxonMobil	Hydro	Pollution
Engie	Covia Holding	Wind	Waste
Eni	First Solar	Biomass	Plastic
Gruppa Lotos	Halliburton Comp	Geothermal	Footprint
Hellenic Petroleum	Hess Corp	Marine	Aerosol
Hera	Marathon Oil Corp	Tidal	Global warming
Motor Oil Hellas	Ni Source	Petrochemical	Emissions
National Grid	Occidental Petroelum Corp	Petrol	Greenhouse gas
Neste Oyj	Philips 66	Petroleum	Air quality
Lukoil	Schlumberger	Ethanol	Sea level
OMV AG	Sempra Energy		Climate change
Orsted	Sun Power		Extreme weather
Pennon Group			Natural resources
Petrofac			Biodiversity
PKN ORLEN			Toxic
Repsol			Extinction
Rosneft			Nitrogen cycle
Royal Dutch Shell			Ocean acidification
Rubis			Land use
RWE			Fresh water
Saipem			Depletion
Saras			Chemical Pollution
Siemens Gamesa			Overexploitation
Snam			Sustainability
Tecnicas Reunidas			Ecosystem
Tullow Oil			
Tupras			
Vallourec			
Vestas			
Enel			

Period: January 2017 - December 2020
Data bases: GDELT & Yahoo Finance
Query example: Anadarko + Fossil Fuels + Climate change
Programming language: Python
*Publicly listed Thomson Reuters Top 100 Global Energy Leaders Ranking 2019 in American stock exchanges

7.2. News analysis methodology

For the download, cleaning, and analysis of the news data, I developed an algorithm powered by

python capable of downloading all global news that contains a combination of keywords of the data dictionary (Table 1). This combination of keywords creates more than 40,172 different queries that the algorithm sends to GDELT. Then GDELT returns all the news that contain the combination of keywords in the data dictionary, 486,932 to be exact.

All this news was segmented thanks to Natural Language Processing techniques (GDELT Global Knowledge Graph (GKG) Version 2.0) by the tone of the news (positive, negative, or neutral) and by volume intensity (the combination of the number of times the news is read and its coverage).

For the tone of news, GDELT uses 51 data dictionaries, including the following popular dictionaries that have been high-lighted in the literature: "Harvard IV-4 Psychosocial Dictionary" "Harvard IV-4 Psychosocial Dictionary" (Stone et al., 1966), the "WordNet-Affect dictionary" (Strapparava et al., 2004; Valitutti and Strapparava, 2004), the "Loughran and McDonald Sentiment Word Lists dictionary" (Loughran and McDonald, 2016; Loughran and McDonald, 2011).

To be considered a high-volume news, there should be a deviation of two standard deviations in the volume intensity from the mean of all the news. Two standard deviations above the mean represent between 2.5% and 5% of the total sample, thus guaranteeing that I analysed the tail of the distribution, which translates into the analysis of the news with the highest volume intensity.

The high-volume news are the events in the event study.

7.3. Event study methodology, expected return models and significance analysis

To measure the economic impact of the high-volume news, this work has followed the methodology of Brown and Warner (1985) for the event study, with the day of the event being the day of publication of the high-volume news. As previous Finance research concluded, capital markets reveal all possible information about companies in their stock prices. So, thanks to the event study methodology, one can analyze how a singular event alternates the company's forecasts by quantifying the event's impact on the company's stock price. Among the scientific literature, the most common form to perform this type of analysis is using the stock returns, and to a lesser extent, using volumes and volatilities. I have studied cumulative abnormal average returns (CAAR) and abnormal volatilities (AV).

The CAAR aggregates and cumulates the abnormal returns (AR) for all n stocks to find the average abnormal return at each time *t*. AR are calculated by deducting the returns that would have been happened if the studied event would not have occurred (normal returns) from the factual returns of the stocks. While the actual returns can be empirically observed, the normal returns need to be estimated. For that, expected returns models must be calculated.

The AV measures the variability or fluctuations of the returns of a financial asset, of interest rates and, in general, of any financial asset in the market. If an asset's price moves plenty and very fast,

that price is said to be very volatile. Volatility shows how the profitability of a financial asset has deviated from its historical average. Therefore, the standard deviation is used as an indicator of volatility. Consequently, a high standard deviation means that the returns of the analysed assets have experienced substantial variations. In contrast, a low standard deviation indicates that these returns have been much more stable over time. Understandably, the greater the standard deviation, the greater the potential loss for the shareholder.

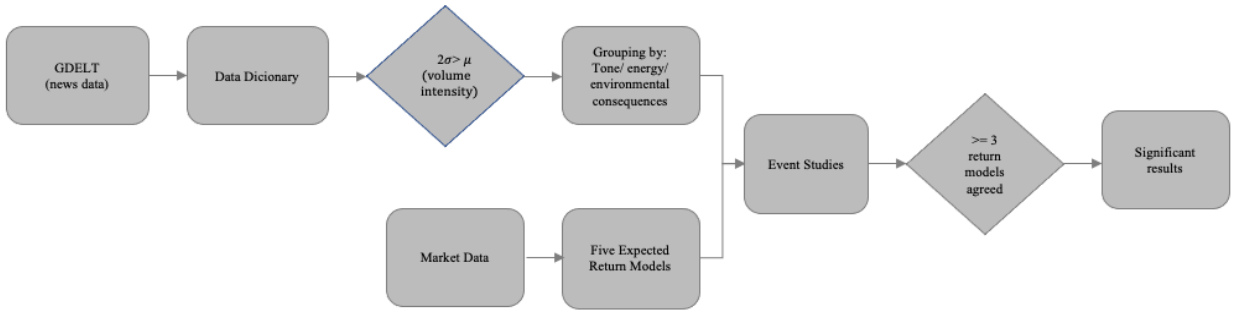
For the thesis event study analysis, we grouped the high-volume news by type of energy (energy keywords), environmental consequences (sustainability keywords), and tone (i.e.: Coal, CO2, positive tone). There were 1,485 combinations. For each of those combinations I performed the event study analysis of the CAAR and the AV.

For the analysis of the CAAR I used the event study methodology with five different expected return models. I performed 14,850 CAAR event studies, that correspond to the 1,485 combinations (i.e.: Coal, CO2, positive tone) multiply by five expected return models. However, only 7,429 had enough data (high-volume news) to perform an event study, because, following Bartholdy, Olson, and Peare (2007), any event study with less than 50 events has been eliminated from the analysis to guarantee an acceptable sample size and robustness in the statistics results.

To make this dissertation more statistically robust, I only considered that an event study was statistically significant if at least three of the five expected return models must conclude so.

For the AV, 1.170 event studies were performed with single-day test statistics.

Graph 1, Methodology summary



CAAR Methodology:

According to MacKinlay (1997), to determine the lead of events to analyze the CAAR, the following characteristics should be considered:

- The day of the event: Day of publication of the news. If various news items explain the same content within a 15-day window, the news item with the highest volume intensity index will be used as the event date.

- Event window: the event window is [-7, 7]. By calculating the accumulated abnormal returns in 15 days, we can more accurately determine the variation or abnormal return that sustainability news can cause to the companies analysed. The window is so wide to collect all the information emitted by different media, explaining the same content.
- Estimation window: a 100-day pre-period is taken for each of the events described in the previous section. To quantify the economic impact of a particular event using return event studies, one needs to use abnormal returns. Abnormal returns result from diminishing the returns that the company would have had if the investigated event would not have happened (expected returns) from the stocks' actual returns. These calculations are made with data of the estimation window.
- Expected return models: The models used for CAAR are the following: Market model, Market adjusted, Comparison Period Mean Adjusted, GARCH and EGARCH.

-Market model (mm), the most used analysis for the event study methodology. This model looks at the actual returns of a baseline reference market and tracks the correlation of a company's stock with the baseline. Equation (1) and (2) specifies the model. The abnormal return on a particular day, $AR_{it,}$ in the event window describes the difference between the actual stock return, R_{it}, on day *t*, and the expected return, which is foretold based on two facts; the average relationship between the firm's stock and its reference market (expressed by the α and β parameters), and the actual reference market's return, R_{mt}.

$$R_{it} = \alpha_i + \beta_i \cdot R_{mt} + \varepsilon_{it}, \quad (1) \qquad \text{then} \quad AR_{it} = R_{it} - (\alpha_i + \beta_i \cdot R_{mt}). \quad (2)$$

-Market adjusted (mam), model widely used to control the event's possible effects, the publication of the sustainability news in this case, in the stock market. In the market adjusted model, the observed return of the market on day t R_{mt} is subtracted from the return R_{it} of the observation i on day *t*. We get for the abnormal return:

$$AR_{it} = R_{it} - R_{mt}. \quad (3)$$

-Comparison Period Mean Adjusted Model (cpmam), the abnormal return in the event window is the return of observation *i* on day *t* minus the average return of the observation i in the estimation window:

$$AR_{it} = R_{it} - \bar{R}_i, \quad (4), \text{ where } \bar{R}_i = \frac{1}{T_1 - T_0} \sum_{t \in [T_0, T_1]} R_{it}. \quad (5)$$

-Market Model GARCH error estimation (garch), uses a single factor market model with GARCH (1, 1) errors estimated, specifically:

$$R_{it} = c_i + \beta_i R_{mt} + \gamma_i D_{it} + \varepsilon_{it}, \quad (6)$$

The conditional variance (Bollerslev 1986) may be written as:

$$\sigma_{it}^2 = \alpha_{i0} + \alpha_{i1} \varepsilon_{i(t-1)}^2 + \lambda_i \sigma_{i(t-1)}^2 + \delta_i D_{it}. \quad (7)$$

where D_{it} is a dummy variable which takes 1 on the disclosure day *t* and 0 otherwise for firm *i*; σ_{it}^2 and ε_{it} are the volatility and the errors of the firm *i*. Also, R_{it} is the return of firm *i* and R_{mt} is the return of the reference market *m* both on day *t*. Equations (6) and (7) represent the mean and time-varying volatility functions respectively. The abnormal returns and abnormal volatility caused by the publication of sustainability news are measured by γ and δ_i for firm *i*. Parameters are estimated by maximum likelihood (a non-linear solver is used for the optimization problem).

- Market Model EGARCH error estimation (egarch), Nelson (1991) proposed the EGARCH model to include the asymmetric effect of changes in the prices of an asset on its volatility. The Garch (1,1) model does not account for any asymmetry that may arise from the negative and positive moves of the market or as it is usually called, the leverage effect. To solve this, the EGARCH model applies a logarithmic conditional variance. Equation (8) is the conditional variance of the EGARCH (1,1) model:

$$ln(\sigma_{it}^2) = \omega_i + \beta_i ln(\sigma_{i(t-1)}^2) + \alpha_i \left| \frac{\varepsilon_{i(t-1)}}{\sigma_{i(t-1)}} \right| + \gamma_i \frac{\varepsilon_{i(t-1)}}{\alpha_{i(t-1)}}. \quad (8)$$

where ω corresponds to a constant , β is the now logarithmic GARCH term, α is the ARCH term that no longer has to be positive. The γ is the so-called leverage term; if is significant and different from zero there will exist asymmetry in estimation period. The σ is the standard deviation.

The expected returns have been obtained from the estimated coefficients for each company and event, using a pre-event period that begins on day −120 and ends on −20, with day 0 being the day of publication of the high-volume News. Given the nature of the information examined, it is interesting to analyze the market reaction around the event date, since there could be an anticipated reaction due to possible leaks of the information or also a delayed reaction. To study these possible effects, the period [−7, +7] has been used as the event window.

Cumulative abnormal returns (CAR_{it}), refers to the sum of abnormal returns (AR_{it}) over a given period of time, the event window [−7, +7].

$$CAR_{it} = \sum_{t=t1}^{t2} AR_i. \quad (9)$$

Average Abnormal Returns (AAR_t) aggregates the abnormal returns (AR_{it}) for all n stocks to find the average abnormal return at each time *t*.

$$AAR_t = \frac{1}{n} \sum_{i=1}^{n} AR_{it}. \quad (10)$$

Cumulative Average Abnormal Return ($CAAR_t$), illustrated in equation (11) adds the average abnormal daily return for the intervals within the event window , [−7, +7].

$$CAAR_t = \sum_{t=t1}^{t2} AAR_t. \quad (11)$$

The hypotheses of this study were analysed using a parametric test, i.e., the skewness-adjusted t-test (Hall, 1992) As documented in Fama (1965), Press (1967), Kon (1984), Gray and French (1990) and Aparicio and Estrada (2001), stock returns are not normally distributed and tend to be skewed. The authors of Pindick (1983), French, Schwert and Stambaugh (1987) and Campbell and Hentschel (1992) suggested that this is because news increases the volatility of stocks, which magnifies their returns (especially negative news). Over 50 years ago, the authors of Fama (1970) pointed out that the way investors interpret the information around them affects market efficiency.

In the case of this investigation, the returns were skewed as we performed event studies that were segmented by tone: the negative and neutral news items were negatively skewed, and the positive items were positively skewed.

The authors of Lyon, Barber, and Tsai (1999), Banik and Golan Kibria (2011) and Cojbasic and Loncar (2011) found that the skewness-adjusted t-test that was introduced by Hall (1992) performed as well as equivalent non-parametric tests, as long as the sample size was not small.

Recalling the (unbiased) cross-sectional sample variance as:

$$\sigma(CAAR_t) = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(CAR_{it} - CAAR_t)^2}. \quad (12)$$

Then the skewness estimation focused on averaged abnormal returns is specified by:

$$t_{skew} = \sqrt{n}(S + \frac{1}{3}\hat{\gamma}S^2 + \frac{1}{6n}\hat{\gamma}), \quad (13)$$

$$\hat{\gamma} = \frac{\sum_{i=1}^{n}(CAR_{it} - CAAR_t)}{n\sigma(CAAR_t)^3}. \text{ where } (14),$$

$$S = \frac{CAAR_t}{\sigma(CAAR_t)}. \quad (15)$$

Where $\hat{\gamma}$ is the estimate of the coefficient of skewness and $\sqrt{n}S$ is the conventional t-statistics.

Once the abnormal returns are calculated, is needed to determine if the deviation from the normal return is a statistically significant. For that, a skewness-adjusted t-test is applied with the hypothesis test defined as:

The abnormal returns cannot be distinguished from zero

H_O: CAAR = zero

The abnormal returns can be distinguished from zero

H_1: CAAR ≠ zero

The decision is to reject H_0 if $t_{skew} > t_{critical}$ or p-value < 0.05. This means that the value is statistically significantly different from zero with a significance level of 5%.

This means that if the t_{skew} is greater than 1.96 or minor than -1.96 we reject. If we do not reject because the is less than 1.96 indicates the results are not statistically different from zero.

AV Methodology:

A single-day test statistic was performed to test the effects on the conditional volatility function on the time series (Balaban and Constantinous, 2006). The time series is utilized as a whole, and thus, there is no need of an event window. The market model with GARCH errors was used, based on Equations (6) and (7).

We calculated another cross-sectional t-statistic to test whether the conditional volatility on announcement day is different from the other days across the firms. We used the parametric test: average of cross-sectional-corrected-vy t-test. This statistic standardizes δ_i by the standard deviation of firm i during the entire period:

$$t(\hat{\delta}) = \left\{ \sum_{i=1}^{n} S_{i/n} \right\} / \left\{ [1/n(n-1)] \sum_{i=1}^{n} \left[S_i - \sum_{j=1}^{n} S_j/n \right]^2 \right\}^{0.5} \quad (16)$$

Where $S_i = \hat{\delta}/\hat{\sigma}_{i,0}$ represents the adjustment of $\hat{\delta}_i$ by the estimated volatility of firm *I* on the day of the publication of the sustainability news.

To test if the Abnormal Volatilities are statistically significance, we used the Cross-Sectional-Corrected-Vy-t-Test with a significance level of 5% as performed with the Abnormal Returns.

The event studies were carried out in the Python software environment, using the 'EventStudy' package by Schimmer, Levchenko, and Müller (2014) hosted on RapidAPI.

8. Thesis structure

The rest of the doctoral thesis will be organised as follows.

First, the research carried out to elaborate concise objectives will be presented in Chapter one. It should be noted that this chapter was presented at the XXI Congreso Internacional AECA: Business and society: sustainability and digital transformation.

Then Chapter two and three will be presented, the first analysing leading European energy firms and the second the ones in the United States of America. The first chapter has been published in the scientific journals Applied economics and the one analyzing United States is under review in in the special issue "The Effects of Green Finance and Promotion Policies on Green Energy Development and Environmental Management" of International Journal of Environmental Research and Public Health (ISSN 1660-4601) .

The fourth chapter will compare Europe and the United States of America, before and during the pandemic COVID-19. This chapter is currently under review in the Journal Sustainability.
Finally, the common conclusions will be presented.

9. Chapter one

The Business Case of Adopting Corporate Sustainability Measures and How It is Reflected in the Income Statement: A Literature Review

9.1. Introduction

In the sustainable development era, the interest in knowing whether companies with high corporate sustainability performance (CSP) generate higher financial returns than business as usual has not stopped growing, both in terms of academia and financial markets (Cornell and Damodaran, 2020; de Matos, 2020; Pinney et al., 2019; Ruggie and Middleton, 2019; Sikacz 2017; Zainuldin and Lui, 2021). We define a company with high CSP as one whose activity and performance are expected to last in the long term while maintaining society's economic, social, and environmental welfare (Formentini and Taticchi, 2016; Hassini et al., 2012, Wagner 2010).

Investors, stakeholders, and researchers have different options to comprehend and value the commitment of the company to its environment: news media, inclusion in sustainability index, audits carried by independent experts and the information provided by the company through corporate social responsibility (CSR) reports (Gray et al., 2001; Kolk, 2005).

Today, CSR has risen as a critical factor in making business decisions (Cochran, 2007). Most of the companies are required by their stakeholders to continue their activity with corporate responsibility, that is, respecting the environment and human rights (Stubbs and Cocklin, 2007; Agnolucci and Arvanitopalos, 2019; Shahbaz et al., 2020). The raised interest of large corporations regarding social responsibility is visible in the increasing number of CSR reports (Campbell, 2004). According to Russell 1000 Index Sustainability Reports 2019, 90% of the companies on the S&P 500 Index published a CSR report in 2019.

Some indexes, such as the Dow Jones Sustainability, STOXX, Ethibel Excellence, Morningstar Socially Responsible Investment Index, among others, are indicators of how investors evaluate social responsibility and how these actions return on creating business value (Barnea and Rubin 2010; Nakai et al., 2012; Webb, 2005). These indexes were designed to guide investors interested in socially responsible investments (SRIs), to discover companies committed to sustainability. Of course, the SRI does not intend that companies neglect their risk objectives and financial profitability. However, it also incorporates environmental, social and governance issues in investment analysis and asset selection.

Companies are raising their interest in being listed as socially responsible businesses and becoming part of ethical stock indexes, among other reasons because part of these indexes attracts capital from institutional investors. These investors are increasingly becoming aware that proper management of the social and environmental concerns of the company influences the value of the company in the medium and long term (Aouadi and Marsat, 2016; Oberndorfer et al., 2013; Flammer, 2013; Webb 2005).

Therefore, it can be said climate awareness and CSR are changing investment patterns. For example, Laurence D. Fink, the founder and chief executive of Blackrock, the world's largest investment fund

managing $7 trillion, announced in 2020 that sustainability will be the core of its investments and that his fund will be disinvesting in fossil energy companies henceforth (New York Times, 2020). However, Blackrock is by no means the first investment fund that reflects the growing environmental awareness of the investors. In fact, in December 2019, 631 investors handling $37 trillion signed a letter urging governments to curb climate change and meet the objectives of the Paris agreement. However, these significant investment funds have also historically been the primary sources of investment for fossil fuel companies.

According to the Global Sustainable Investment Review 2018, investments in sustainable assets were around $31 trillion, an increase of 34% since 2016. They also highlighted that SRIs represented between 18% in Japan and 63% in Australia and New Zealand of all professionally managed assets. The scientific literature had also echoed this trend, and many authors had analysed the exponential increase in SRIs (Pinney et al., 2019; Ruggie and Middleton, 2019; Unruh et al., 2016; Andersson et al., 2016).

Due to the significant growth of CSR reports and SRIs, the scientific community is investigating how the market reacts in terms of economic profitability to the socially responsible attitude of the companies. As mentioned above, this kind of investment is dragging an increasing number of investors; however, they are, nevertheless, a minority compared to the number of conventional investors, defining them as those who only seek profit maximisation. Therefore, researchers want to understand if, for these conventional investors that drive most of the market, CSP is a fundamental factor and how they can consider it: positively, negatively, or neutrally.

Among the previous literature and finding positive relationships, the Center of Sustainability and Excellence research stands out, and it detected an apparent correlation between sustainability and financial results in North America. They found that 75% of companies with sustainability reports and high CSR reported better financial results than the previous years (Sustainability Reporting Trends in North America, 2020). Munir et al. (2019) studied a sample of 425 Australian listed firms; using a structural equation modelling approach, they found that CSR was linked to CSP and led to improved financial performance. Yin et al. (2019) showed positive relationships between the dissemination of CSR information and profitability; these results were valid for high CSR companies and for those that did it so symbolically. Alshehhi et al. (2018) used content analysis to examine 132 top-tier journals and found that 78% of the analysed publications reported a positive relationship between CSR and financial performance. Other studies that concluded that CSR enhances financial performance are Lu and Taylor (2016) and Charlo et al. (2017).

Finding no significant reaction or a negative one, Curran and Moran (2007) analysed the reaction of British companies concerning their inclusion in the FTSE4Good UK 50 Index, an index evaluating CSP, finding no statistically significant reaction. Cheung (2011) examined US companies included

in the Dow Jones Sustainability World Index (DJSI World) and found a positive reaction in the short term. Consolandi et al. (2009) also found a positive market reaction to the inclusion of companies in the Dow Jones STOXX 600 Index. Finally, authors like Oberndorfer et al. (2011) noted that inclusion in these indexes can be interpreted by investors negatively. Thus, according to this evidence, the inclusion in a sustainability index is a reaction to institutional pressures. These pressures require new business activities that have resulted in additional unproductive expenses. This argument is recurrent among some researchers who argued that investing in sustainability destroys the wealth of the shareholders because they consider it merely an expense (Friedman, 1970; Clotfelter, 1985; Navarro, 1988; Galaskiewicz, 1997). However, these arguments are becoming less frequent and relate more to the past.

The event study methodology is also frequent among scientific literature, to measure the relationship between environmental and CSR measures and financial performance. An event study tries to measure the valuation effects of a corporate event by examining the response of the stock price around the announcement of the event.

Many of these investigations had concluded that the stock market reacts positively to positive CSR news, reports, and social media and negatively otherwise. For example, the first group of researchers focused on analysing the impact on the stock price on negative CSR news, highlighting a negative impact (Blacconiere and Patten, 1994; Hamilton, 1995; Klassen and McLaughlin, 1996; Konar and Cohen, 1997; Khanna et al., 1998; Dasgupta and Laplane, 2001; Grand and D'Elia, 2005; Gupta and Goldar, 2005). This relationship has been noted recently in disasters like the BP Gulf of Mexico (2010) and the nuclear accident at the Fukushima plant in Japan with Tokyo Electric Power Company (2011). The second group of studies has focused on the analysis of the market reaction to positive CSR news, with Wingender and Woodroof (1997), Yamashita et al. (1999), Filbeck and Gorman (2004) and Nagayama and Takeda (2006) finding positives returns.

There is no consensus on the empirical results of the existing literature being inconclusive (Trumpp and Guenther 2017). Xi et al. (2019) and Munir et al. (2019) argued that the lack of consensus among researchers could be the wide range of metrics to measure financial performance and the broad CSR concepts.

That is why the scientific community should keep working on a framework as Grewal and Serafein (2020) stated, "…researchers have spent little effort to measure corporate sustainability performance… we view this space as the single biggest opportunity for researchers to advance the field."

Consequently, the purpose of this paper is to carry out state-of-the-art research on the economic impact on companies being compromised with CSR. For that, we have analysed the 200 most cited

scientific papers until May 2018 with the keyword 'Corporate Sustainability Performance', using the Scopus database.

To put in context why the election of the phrase, 'Corporate Sustainability Performance', and inspired by the economic Nobel Prize, J. Shiller, in his book, Narrative Economics, I used ProQuest and Google Ngrams to analyse when the research started its evolution. Using ProQuest, we discovered that it first appeared in scholarly journals in 1969, and since then, the phrase has been used in 51,075 scientific papers, 153,259 books and 95,801 reports. Through Google Ngrams, we learned that since the first book used this phrase in 1989, it has grown in book literature exponentially, 26.011% in just over 20 years. This exact search was carried out with several other terms, and in none of them was an exponential distribution like that of 'Corporate Sustainability Performance'. The other searches were 'Corporate Sustainable Performance', 'Corporate Sustainability Impact', 'Corporate Sustainability Value', 'Corporate Sustainability Business Case', 'Corporate Sustainability Profitability', 'Corporate Sustainability Cost Effectiveness' and 'Corporate Sustainability Economic Performance'.

We analysed the 200 most cited papers of the 1,778 search results since they represent almost 80% of the total citations, following a pareto distribution. From the 200 most cited papers, we carried out a bibliometric study and an expert analysis. Regarding the expert analysis, we read and analysed all the articles and then classified them regarding the methodology used, theme, economic impact, and the articles' tone. With all this information, we have obtained a complete knowledge of sustainability research and its performance.

Among the most prominent findings, these stand out:

- The most cited articles
- The most productive journals
- The most widely used keywords
- Segmentation by type of study
- Segmentation by theme
- Segmentation by the existence or not of economic impact
- Segmentation by type of economic impact
- The tone of the article (pro-sustainability, critical or neutral)

The motivation of this study is to know if being sustainable, besides being the most ethical and respectful option with the environment, is also an economically profitable alternative. We question, has invested in sustainability an economic return? It means, are economic profits for the investors or the benefits that sustainability actions generate are only attributable to the environment?

This paper's originality and contribution cover the need for an updated study that analyses the economic consequences for a company to be sustainable. Combining a bibliographical analysis with

expert analysis, this study offers a better picture of how sustainability affects companies from a business point of view. Analysing the 200 most cited articles on the subject, we can discover the research trends and the most frequent economic reactions on sustainability.

9.2. Materials and Methods

The proposed analysis has been made from a bibliographic search in the Scopus database. Scopus is the largest abstract and citation database of peer-reviewed literature, scientific journals, books, and conference proceedings. It covers approximately 18,000 titles of more than 5,000 international publishers, including coverage of 16,500 peer-reviewed journals in the areas of science, technology, medicine, and social sciences, including arts and humanities. It is edited by Elsevier and is accessible on the web for subscribers. Searches in Scopus incorporate searches of scientific websites through Scirus, Elsevier and patent databases.

The search has been organised by subject. The term 'Corporate Sustainability Performance' has been introduced in the topic line of the Scopus database, and the 200 most cited articles have been downloaded (May 2018). The data were downloaded and exported by selecting all the export fields offered by the tool. The extracted data are the paper's title, authors, year of publication, magazine, keywords, SciVal topic prominence and the number of citations of the articles.

Once all this information was extracted to a single spreadsheet, the data was processed so we could analyse,

- The most relevant articles by numbers of citations.
- Historical distribution of the most cited articles on 'Corporate Sustainability Performance'.
- The most productive and cited authors.
- The most productive and cited Journals.
- The most common keywords that summarise the main topics.

Once the bibliometric study was carried out, an expert analysis was made. The expert analysis was carried out by reading all the articles of the sample. After this reading, they were classified according to,

- Countries of study.
- Type of study.

Analytical studies: the articles interpret data statistically and with significant samples, so their results are broader and should not be biased.

State of the art or business framework: articles that compile existing literature about sustainability and its business application.

Case study: articles analysing sustainability success cases of companies or countries.

New indicator proposal: to measure sustainability performance in any corporate area.

New reporting proposal: to inform stakeholders of corporate sustainability performance for the whole company.

Negative critiques: to previous literature, sustainability indicators or reporting methods.

- Theme.

Sustainability practices: articles that analysed the effects on companies incorporating social responsibility into their business strategy.

Sustainability indicators: articles that study or propose sustainability meters as a quantitative foundation to inform the company's sustainability management.

Sustainability reporting: articles that study or propose sustainability reports as an information tool for stakeholders about the companies' economic, environmental, social and governance performance.

- The economic impact in the income statements found in the analysed articles.
- Operating profits on the income statements found in the analysed articles.
- Financial profits on the income statements found in the analysed articles.
- The tone of the article: Pro-sustainability, Critical or Neutral.

It is worth noting that some of the 200 articles analysed can be classified into more than one of the expert analysis categories; for example, it can have an operational and financial impact; or be a negative critique and a proposal of a new metric. Also, five of the 200 articles analysed had nothing to do with the topic of the study, so they were eliminated from the sample. The articles exclusion criterion was based on reading all the articles in the sample. All those that did not analyze the CSP from an economic or financial point of view were excluded. The five eliminated articles focused on engineering, physics, and statistics performance, not economics.

9.3. Results

9.3.1. *Bibliometric Study*

The bibliometric analysis started by identifying the articles most cited by the other authors, to support their research about CSP (Table 2). We found that the most cited articles correspond to Seuring and Müller (2008), with 1,566 accumulated citations. These articles review the literature on sustainable supply chain management between 1997 and 2007; they also complement the research with a conceptual framework that summarises and categorises all previous studies in the field (Seuring and Müller, 2008). The second most cited article is from Lazonick and O'Sullivan (2000); they perform a historical analysis of the rise of shareholder value as a principle of corporate governance in the US and how US companies have transformed towards a corporate governance strategy. Aguinis and Glavas (2012) have the third most cited article in this study; they carried out state-of-the-art research on CSR, where they synthesise and integrate the literature at the institutional, organisational, and individual levels of analysis. In the fourth position, we find Clarkson et al. (2008); these authors carry out a study with 191 American companies looking for the relationship between environmental

performance and environmental disclosure and finding a positive correlation. In position number 5 is Singh et al. (2009); this study overviews the sustainability indicators analysing their strategy, scaling, normalisation, weighting, and aggregation methodology.

Table 2, Most relevant articles of Corporate Sustainability Performance according to Scopus

Title	Author 1	Author 2	Author 3	Author 4	Datum	Journal	Citation
1.From a literature review to a conceptual framework for sustainable supply chain management	Seuring, S.	Müller, M.			2008	Journal of Cleaner Production	1,566
2.Maximizing shareholder value: A new ideology for corporate governance	Lazonick, W.	O'Sullivan, M.			2000	Economy and Society	723
3.What We Know and Don't Know About Corporate Social Responsibility: A Review and Research Agenda	Aguinis, H.,	Glavas, A.			2012	Journal of Management	598
4.Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis	Clarkson, P.M.	Li, Y.	Richardson, G.D.	Vasvari, F.P.	2008	Accounting, Organizations and Society	551

5.An overview of sustainability assessment methodologies	Singh, R.K.	Murty, H.R.	Gupta, S.K.	Dikshit, A.K.	2009	Ecological Indicators	537
6.Developing intellectual capital at Skandia	Edvinsson, L.				1997	Long Range Planning	510
7.Sustainable supply chain management: Evolution and future directions	Carter, C.R.	Easton, P.L.			2011	International Journal of Physical Distribution and Logistics Management	407
8.Developing a framework for sustainable development indicators for the mining and minerals industry	Azapagic, A.				2004	Journal of Cleaner Production	395
9.Assessing the sustainability performances of industries	Labuschagne, C.	Brent, A.C.	Van Erck, R.P.G.		2005	Journal of Cleaner Production	362
10.An overview of sustainability assessment methodologies	Singh, R.K.	Murty, H.R.	Gupta, S.K.	Dikshit, A.K.	2012	Ecological Indicators	344

Source: Own elaboration from the data of Scopus

In Table 3, we again analyse the most cited articles. Instead of explaining it by total citations, this time, we analyse the number of average citations per year to avoid temporary bias. In this new table, we can see that the first most relevant article continues being Seuring and Müller (2008), while the second and third positions change to Aguinis and Glavas (2012) and Singh et al. (2009), respectively.

Table 3, Most relevant articles of Corporate Sustainability Performance according to Scopus in annual average

Tittle	Author 1	Author 2	Author 3	Author 4	Datum	Journal	Citation	Average citation per year
1.From a literature review to a conceptual framework for sustainable supply chain management	Seuring, S.	Müller, M.			2008	Journal of Cleaner Production	1566	156.60
2.What We Know and Don't Know About Corporate Social Responsibility: A Review and Research Agenda	Aguinis, H.,	Glavas, A.			2012	Journal of Management	598	99.67
3.An overview of sustainability assessment methodologies	Singh, R.K.	Murty, H.R.	Gupta, S.K.	Dikshit, A.K.	2009	Ecological Indicators	537	59.67
4.Sustainable supply chain management: Evolution and future directions	Carter, C.R.	Easton, P.L.			2011	International Journal of Physical Distribution and Logistics Management	407	58.14
5.An overview of sustainability assessment methodologies	Singh, R.K.	Murty, H.R.	Gupta, S.K.	Dikshit, A.K.	2012	Ecological Indicators	344	57.33
6.Revisiting the relation between environmental	Clarkson, P.M.	Li, Y.	Richardson, G.D.	Vasvari, F.P.	2008	Accounting, Organizations and Society	551	55.10

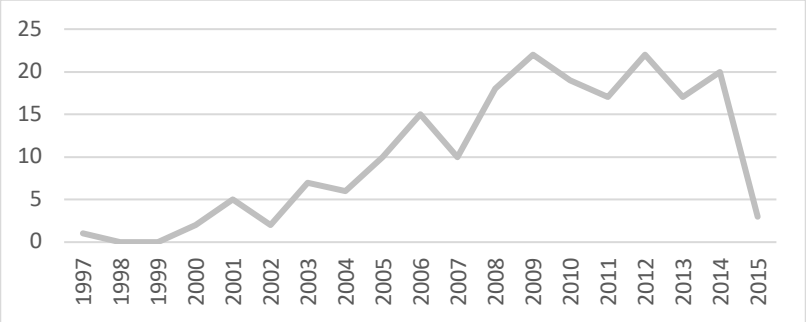
performance and environmental disclosure: An empirical analysis								
7.Maximizing shareholder value: A new ideology for corporate governance	Lazonick, W.	O'Sullivan, M.			2000	Economy and Society	723	40.17
8.Developing a framework for sustainable development indicators for the mining and minerals industry	Azapagic, A.				2004	Journal of Cleaner Production	395	28.21
9.Assessing the sustainability performances of industries	Labuschagne, C.	Brent, A.C.	Van Erck, R.P.G.		2005	Journal of Cleaner Production	362	27.85
10.Developing intellectual capital at Skandia	Edvinsson, L.				1997	Long Range Planning	510	24.29

Source: Own elaboration from the data of Scopus

Figure 1 shows that the number of articles published on Corporate Sustainability Performance follows a growing trend in recent years, except for a drop in 2015. This fall of articles in 2015 and the non-existence of articles in consecutive years can be because we are analysing the 200 most cited articles, so these new articles have had fewer opportunities to be cited. However, that does not necessarily mean that scientific production has dropped.

The first article that appears published dates from 1997 (Edvinsson, 1997), and it is a Swedish company's study case. This company developed a new method of reporting in the '90s; it considered the financial and non-financial issues. It highlights the high importance for the company's performance to value and account for intellectual capital.

Figure 1, Temporal distribution of the most cited articles on corporate sustainability performance



Source: Own elaboration from the data of Scopus

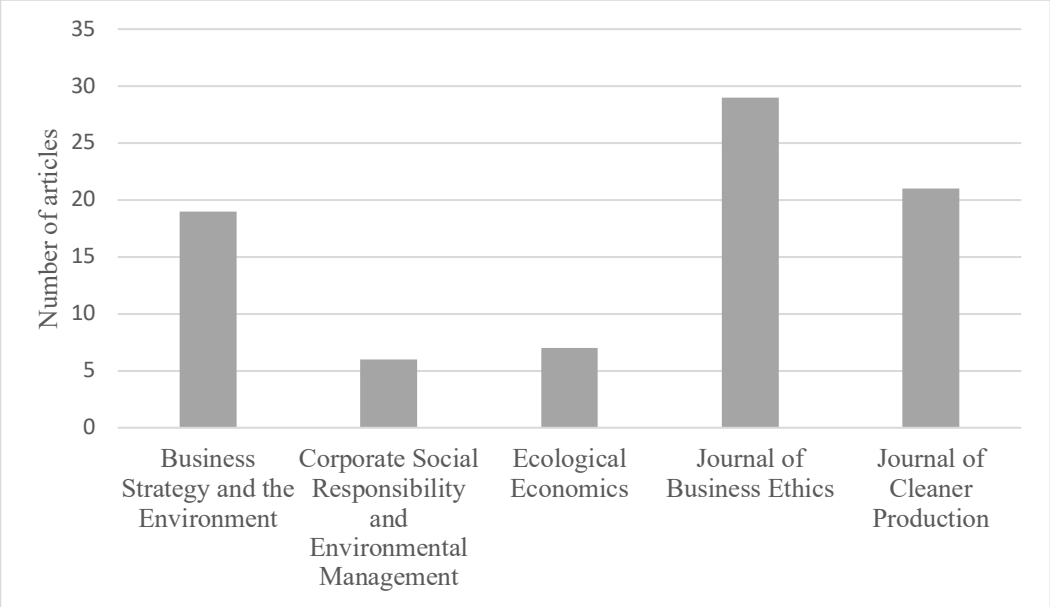
In Table 4, we can see the most productive authors of the sample. Among them, Marcus Wagner stands out, with five articles published (Wagner, 2005; Schaltegger and Wagner, 2006; Wagner, 2010; Kuckertz and Wagner, 2010; Hall and Wagner, 2012) have been published between 2005 and 2012, except for one all are statistical studies; these articles analysed the performance of companies after adopting sustainability practices, finding a positive relationship between financial performance and the adoption of said practices in all cases. The other article published by this author is state-of-the-art research of the different sustainability reporting methodologies.

Table 4, The most productive and cited authors

Most Productive and cited Authors	Number of Articles
Wagner, M.	5
Adams, C.A.	4
Singh, R.K.	3
Seuring, S	3
Searcy, C.	3
Sarkis, J.	3
Rodríguez-Ariza, L.	3
Murty, H.R.	3
Lee, D.D.	3
Hahn, T.	3

Source: Own elaboration from the data of Scopus

Figure 2, The most productive and cited Journals



Source: Own elaboration from the data of Scopus

In Figure 2, we can see the journals with the highest publication of reference articles on Corporate Sustainability Performance, Journal of Cleaner Production, Business Strategy and Environment, Ecological Economics, Corporate Social Responsibility, and Environmental Management. Thus, if we read only these five journals, we would already have 41% of the reference articles.

Table 5, The most frequent keywords

Most used Key words	Number of Articles
Corporate Social Responsibility	60
Sustainability	48
Sustainable Development	29
Corporate sustainability	26
Supply Chain	26
Performance	20
Environmental management	14
Economic sustainability	11
Corporate strategy	10
Environmental performance	9

Source: Own elaboration from the data of Scopus

Moreover, in Table 5, we can observe the most common keywords that summarise the main topics. The first keyword is 'Corporate Social Responsibility', the second is 'Sustainability', which makes perfect sense because, as I said in the introduction, the terms 'Sustainability' and 'Corporate Social Responsibility' have always gone hand in hand. It is not straightforward to analyse one without analysing the other. Nevertheless, it is important to emphasise the difference between both concepts. At the same time, 'Corporate Social Responsibility' refers to the responsibility of companies

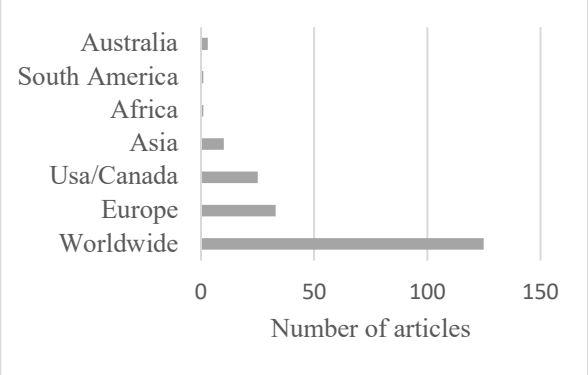
regarding their impact on society at a social, economic, and environmental level. Sustainability refers to the ability of a company to stand on its own, satisfying its needs without compromising future generations. Its field of action also covers ecological, social, and economic factors.

Occupying the third and fourth positions, we find 'Sustainable Development' and 'Corporate sustainability', concepts encompassing sustainability from an economic and business point of view. Then, the resulting most frequent keywords refer to the performance or strategy of the companies.

9.3.2. *Expert Analysis*

The first expert analysis identifies the country or region over which the research has been done. In Figure 3, we can see how, in most cases, research is carried out in developed countries. Even though the bulk of the studies are categorised as worldwide, they only include developed economies.

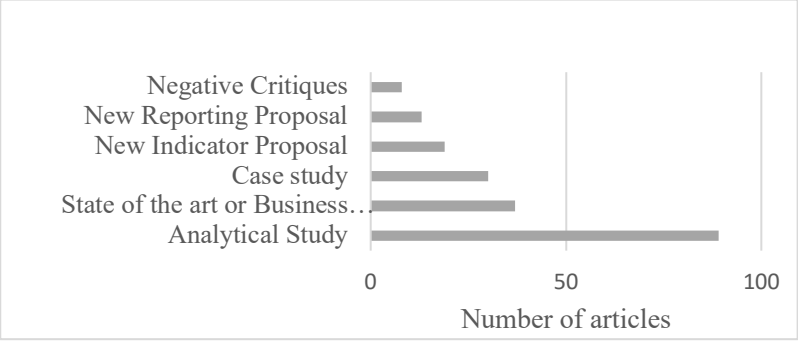
Figure 3, Place of study



Source: Own elaboration from data of the articles

This result is not surprising at all since the rich countries have the resources to be upright. In contrast, the developing countries must first deal with poverty, redistribution, and economic model problems. Figure 4 shows the classification by type of research (methodology used).

Figure 4, Type of study



Source: Own elaboration from data of the articles

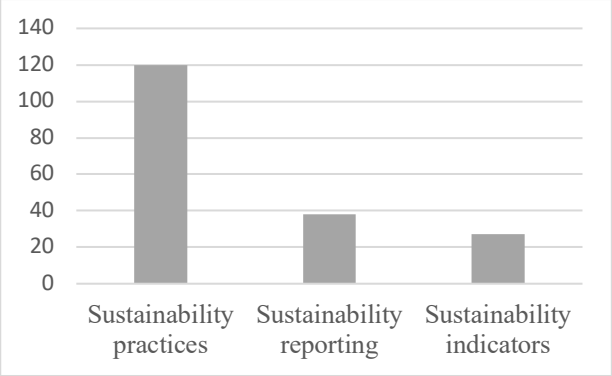
Analytical studies are the most frequent in the sample. This type of article interprets data statistically and with significant samples, so their results are broader and should not be biased. After them, we find articles that do a compendium of existing literature about sustainability, for example, defining the concept of sustainability as its application in the business and always using data and information

from existing literature. The third more frequent type of article is case studies; they focus on analysing sustainability success cases of companies or countries. Next are articles proposing new sustainability indicators or new sustainability reporting methods. Moreover, lastly, there are critical articles with sustainability indicators or reporting methods.

In Figure 5, we examine the article's theme. For better understanding, here is a brief description of each term,

- Sustainability practices: articles that analysed the effects on companies incorporating social responsibility into their business strategy
- Sustainability indicators: articles that study or propose sustainability meters as a quantitative foundation to inform the company's sustainability management
- Sustainability reporting: articles that study or propose sustainability reports as an information tool for stakeholders about the companies' economic, environmental, social and governance performances

Figure 5, Article's theme



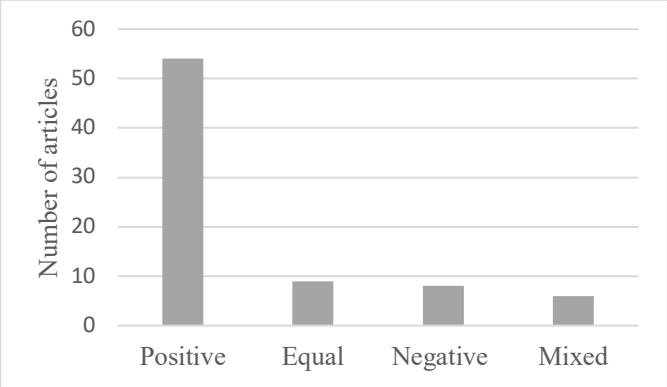
Source: Own elaboration from data of the articles

The existing literature that examines the effect of sustainability on the companies' performance, as seen in Figure 5, focus primarily on sustainability practices. As a result, seven articles in this graph have been excluded from this analysis, as they do not belong to any predominant themes.

Next, we perform a corporate sustainability economic impact detailed study. We selected all the articles in the sample that study the profitability of sustainability in one way or another (new metrics, new practices, use cases, reporting, among others). If there is an economic impact analysis in those studies, the article is within this segmentation; we found 77 articles. Then we classified them according to whether the economic impact was positive, negative, non-existent (equal) or mixed, affecting the income statement positively in some accounts and negatively in others.

Figure 6 shows that most articles that perform studies measuring the economic impact of sustainability find a positive correlation between sustainability and economic performance.

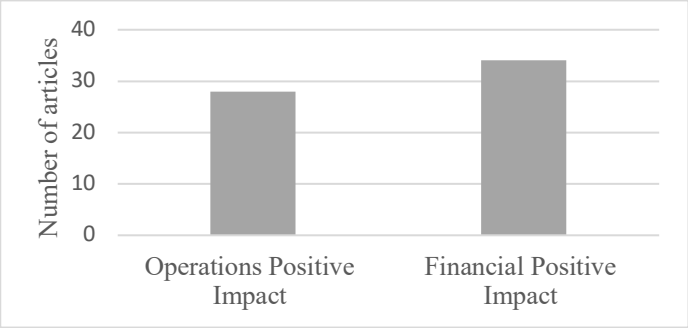
Figure 6, Economic impact



Source: Own elaboration from data of the articles

To understand better how sustainability affects performance, we delve into the analysis of the articles that find a positive correlation between sustainability and economic performance. Figure 7 shows that it similarly affects the company's operating results (for example, an improvement in the supply chain for making it more sustainable reduces costs of the company) and its financial results (increasing the stock price in the stock market after reports news, sustainability).

Figure 7, Positive economic impact

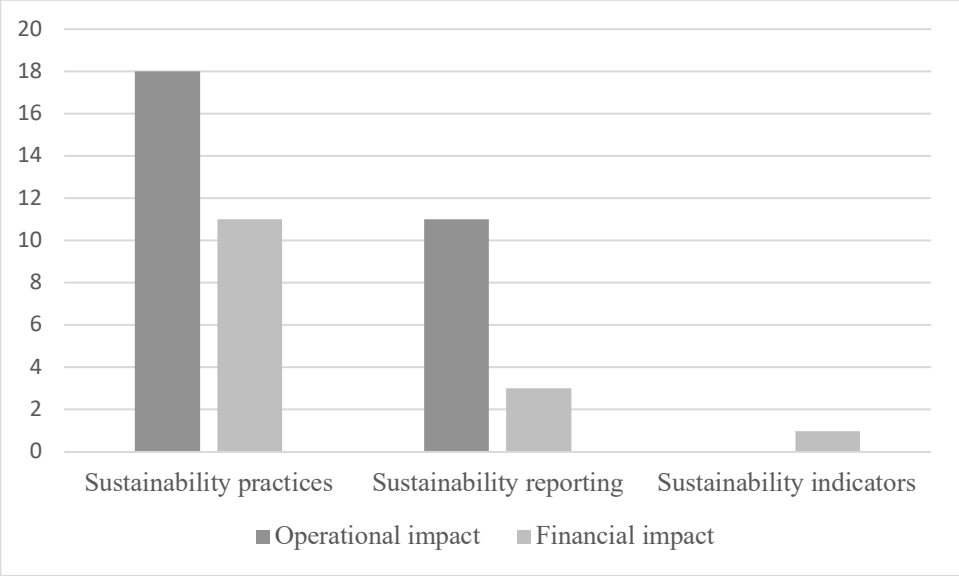


Source: Own elaboration from data of the articles

It should be noted that there are more articles with a positive reaction in Figure 7 than in Figure 6 because, in some cases, we found a positive response in both the operational result and financial result.

In Figure 8, we can differentiate where the positive economic reaction impacts their operational results, impacting the operating income of the companies' income statement or their financial results, meaning changes in their stock price values.

Figure 8, Positive economic reaction by study theme

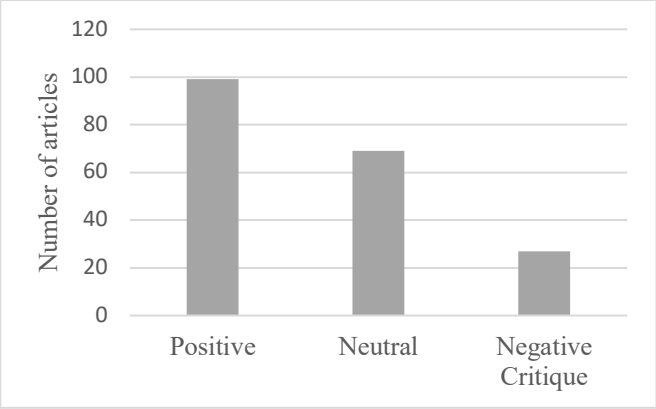


Source: Own elaboration from data of the articles

We observe again that the studies that analyse the sustainable practices are those which have more significant positive economic reactions in quantity in the financial results than in the operating results. The opposite happens with sustainability reporting studies, where we find more positive reactions associated with the firm's operations.

Finally, Figure 9 reflects the tone of the articles. They are positive if the authors are pro-sustainability, betting on it as an engine of change in the economy. They are neutral if the authors do not take sides and only limit themselves to analyse their effects. Moreover, the tone is negative if they criticise other articles that investigate sustainability or advocate that sustainability harms performance.

Figure 9, Article's tone



Source: Own elaboration from data of the articles

After analysing the 200 articles of the sample, we can analyse their trends.

Authors interested in analysing the economic impact of sustainability do so mainly through analytical studies or state-of-the-art research of previous literature. This implies that the analyses are being made from a descriptive perspective, and past economic effects are analysed. Consequently, the

articles that propose new solutions either by proposing new indicators or ways of reporting are the least frequent.

The most outstanding findings of the expert analysis are the confirmation of a positive economic reaction on the income statement in companies that apply sustainability measures. For example, we can see that 70% of the companies that introduce corporate sustainability measures have a positive economic impact (Figure 6), affecting 55% of their financial result and 45% of their operating result (Figure 7).

In any case, it should be noted that correlation is not causation, so, future research should corroborate if the results found in this chapter are the result of causality or if, on the contrary, they results are statistical correlations.

9.4. Conclusions

This investigation aims to analyse the economic impact of being sustainable. We studied the 200 most cited articles about 'Corporate Sustainability Performance'. Analysing these articles, we discovered the research trends and the most frequent economic reactions to sustainability. Thus, this study, combining a bibliographical analysis with expert analysis, offers a better picture of how sustainability affects companies from an economic impact point of view.

The analysis has been made from a bibliographic search in the Scopus database with the subject term being 'Corporate Sustainability Performance', and the 200 most cited articles had been downloaded (May 2018). We processed the data to perform two analyses, a bibliometric study, and an expert analysis.

In the first one, we discovered the most relevant articles by numbers of citations, historical distribution of the most cited articles, the most productive and cited authors, the most prolific and cited journals, and the most common keywords that summarise the main topics.

The expert analysis was carried out by reading and analysing the 200 articles. After this reading, they were classified according to countries of study, type of research, article's theme, the economic impact, if the economic impact was relative to the company's operations or their financial activities, and, lately, the tone of the article (pro-sustainability, critical or neutral).

We got the most cited articles from the bibliometric study, the first one from Seuring and Müller (2008); they reviewed the literature on sustainable supply chains from 1997 to 2007. The second most cited articles are from Lazonick and O'Sullivan (2000), performing a historical analysis of the rise of the stakeholder value because of corporate governance. Finally, the most productive author is Marcus Wagner, with five articles in the sample, four of them statistical studies, finding a positive relationship between financial performance and the adoption of sustainability practices.

The most productive and cited journal is the Journal of Business Ethics, and the most common keywords that summarise the main topics are 'Corporate Social Responsibility', 'Sustainability',

'Sustainable Development'; then, the following frequent keywords refer to the strategy or performance of the companies.

On the expert analysis, we classified the articles according to the type of study, the research theme, and the companies' economic reaction after adopting sustainability measures. We also differentiated the economic impact in 'Operating Impact', economic impacts on the operating income of the companies' income statement results and 'Financial Impact,' meaning financial profits.

The most frequent category of the 200 most cited articles on 'Corporate Sustainability Performance' is the analytical study and literature reviews. Regarding the topic, the most common are sustainability practices.

The most outstanding findings of the expert analysis are the confirmation of a positive economic reaction in companies that apply sustainability measures in their work. For example, we can see that 70% of the companies that introduce sustainability measures have a positive economic impact (Figure 6), affecting 55% of the time their financial result and 45% of their operative result (Figure 7).

This latest finding opens the door to new analytical studies investigating the sustainable economic impact for companies that undertake this path. This research concludes that sustainability has a positive effect on both operational and financial results. Still, it would be very enlightening to continue delving into understanding these positive reactions and their origin. To achieve this, studies must be carried out to analyse both the information provided by the company and the information provided by third parties (stock market indices, press and social network) and see how it affects their market value and sales. In this way, it would be better to observe how the shareholder and the final consumer reacts to sustainability.

This research results from the bibliometric and expert analysis of the 200 most cited articles in the Scopus database using the keywords 'Corporate Sustainability Performance' since it analyses previous research. This article has two research limitations that deserve worth mentioning.

The first and most apparent is the sample size. There are many articles not included in this chapter, that if they had been studied, they could modify the results of this research and the trends found here. However, it should be noted that they represent almost 80% of the total citations.

The second research limitation comes from the expert analysis. When analysing the articles and categorising them for expert analysis, it went through the human filter, so the author's biases could prejudice the results.

The next step is to conduct an empirical study to solve these research gaps or validate the conclusions obtained in this paper. In it, researchers should analyse the economic impact of sustainability through the methodology of an event study.

In this way, we will understand how financial markets react to events related to sustainability, such as the presentation of CSR or ESG reports or even the impact of corporate news related to sustainability.

10. Chapter two

How Shareholders React to Sustainable Narratives about Leading European Energy Companies? An Event Study using Sentiment Data from the Global Database for Events, Language and Tone (GDELT)

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10.1. Introduction

The awareness of climate change and its causes has increased exponentially in recent years (Grimmer and Bingham, 2013; Qader and Zainuddin, 2011). More so since the Paris Agreement (COP25; United Nations Climate Change 2019), where there was an unprecedented worldwide consensus to reduce CO2 emissions and limit the increase in temperature to 1.5ºC warmings above pre-industrial levels.

Climate awareness is changing investment patterns. While environmental, social and corporate governance (ESG) financial investments remain a minority compared to traditional investments, they have increased exponentially, motivated by the increasing attention, acceptance and awareness of climate change (Cornell and Damodaran, 2020; Matos, 2020; Pinney, Lawrence and Lau, 2019; Ruggie and Middleton, 2019). According to Bloomberg and their own compiled data, ESG exchange-traded funds have almost tripled from 2019 to 2020. In addition, the Global Sustainable Investment review of 2018 quantified approximately $31 trillion in sustainable assets, increasing by 34% since 2016.

Confirming the ESG investment trend, BlackRock Inc., the world's largest investment fund with nearly $7 trillion under its management, announced in January 2020 that from then on, it would make sustainability the core of its investments and disinvest in fossil fuels (Sorkin 2020). However, BlackRock is not the first investment fund that reflects investors' growing environmental awareness. For example, in December 2019, 631 investors handling $37 trillion signed a letter urging governments to curb climate change and meet the objectives of the Paris Agreement.

Still, while companies claim to be increasingly sustainable, greenhouse gases are not reducing (Elmalt, Igan and Kirki, 2021). Besides, fossil fuels remain the primary energy source, representing almost 70% of energy production in Europe (European Environment Agency, 2020). Consequently, the stock market's interests are still strongly linked to fossil energy, as they have the dominant energy position. Therefore, there is a clear incentive for companies to appear sustainable and camouflage their interest in the fossil fuel industries.

The scientific community has validated that climate change is factual, but the narrative is not evident for market participants. They face contradictions between the search for high returns and the specifics about greenhouse gas emissions.

Society, regulators, politicians and even investors have increasingly recognised sustainability. However, are companies embracing a more ecological path rewarded by investors? Are they more vulnerable to negative news? Or, on the contrary, do they continue to invest in the business as usual? If investments in ESG continue to grow and greenhouse gas emissions are not reduced, are equity markets incentivising greenwashing?

This research wants to answer how investors react through their investment decisions when corporate sustainability information is released. We have studied this from three different perspectives: from the point of view of profitability (Ang, 2015; Friede, Busch and Bassen, 2015; Kumar et al., 2016; Maiti, 2020; Muhmad and Muhamad, 2020; Sharma et al., 2021), from behavioural economics, to understanding the investors' bias, and are investors able to assimilate the facts and act rationally? Do they overreact to negative information (Olsen, 1998; Shleifer and Vishny, 1997; Tetlock, 2007), and from narrative economics, to understand if there is consensus in the sustainability narrative and which narratives go viral (Shiller, 2019).

This research studies the short-term impact on the stock market of sustainability news for leading European energy companies (Thomson Reuters Top 100 Global Energy Leaders Ranking, 2019). The objective is to understand the average sentiment of the energy shareholder about the sustainability narrative and its impact on its shareholder's value. Since the economic and strategic incentives of the energy investor can vary significantly depending on their current investment portfolio, we have segmented the news according to the tone (positive, negative, or neutral), type of energy generation (fossil fuels, renewables or nuclear) and environmental consequences (CO2, methane, global warming…). Thus, we can analyse investors' reactions in greater detail.

We analysed all sustainability news with high volume intensity about the companies' sample published digitally worldwide from January 2017 to December 2019, through the event study methodology. A total of 279,546 high-volume news was leveraged.

We conducted 4,026 event studies with five different expected return models, to measure the economic impact of sustainability news. The event study methodology analyses, whether a series of events, impact a variable of interest. In this case, the shares' returns, and volatilities are examined by analysing the behaviour of their historical prices and performances.

This study uses the open-source databases Global Database of Events, Location, Language, and Tone (GDELT) for the news and Yahoo Finance for the market data. GDELT is the largest news database worldwide.

The main contribution of this investigation to the existing scientific literature is that it empirically confirms that corporate sustainability news got viral, creating a narrative that impacts shareholder value significantly. Nevertheless, this impact is observed more significantly in the study of volatilities than in the study of returns, indicating a lack of consensus among European energy companies' investors.

These results ratify those of Elmalt, Igan and Kirki (2021), who found that Co2 emissions have not been reduced, although ESG investments continue to increase. We observe that the sustainability narrative is not the same for all investors. Even though the stock market is not isolated from the ecological transition, the interaction of investors is often contrary to the Paris agreements (COP25;

United Nations Climate Change 2019), encouraging companies to continue with business as usual instead of decarbonization.

These results point to a regulatory need to pressure market participants to disinvest from highly carbonised companies, so climate change scientists' narrative is the same for investors.

Another contribution is the magnitude of the study, which guarantees the robustness of the results. We identified 279,546 high-volume news and conducted 3,393 event studies. Therefore, we try to fill the existent literature gap as Grewal (2020) confirm: '…researchers have spent little effort to measure corporate sustainability performance… we view this space as the single biggest opportunity for researchers to advance the field.' Carolina Rezende de Carvalho Ferreira et al. (2016) concluded that more quantitative research is needed to analyse the relationship between sustainability and finance.

Based on the literature survey, no study has investigated the effects on the stock market's capitalization based on all the news published worldwide on sustainability. Several studies have used the event study methodology to measure the connection between environmental measures and financial performance. However, those studies had a smaller sample size, and the information these studies analysed is provided by the companies they analysed, not the media.

Likewise, it is worth highlighting the robustness of the event study. We launched a competition of five different expected return models, accepting only significant results if at least three of the five models provided such a conclusion.

The rest of the chapter is organised as follows: the following section will be the literature review; the third section will detail the sample and the methodology; after that, the results will be shown in the fourth section, and finally, the conclusions.

10.2. Literature review

There is increasing pressure for companies to behave sustainably; however, if market participants do not value those efforts, companies have no real incentive to be or continue to be sustainable (Cheung, 2011). Therefore, it is crucial to understand the market dynamics on sustainability to adjust the regulations that encourage sustainable investments and discourage those that are not.

The scientific literature in this field is extensive and extends to the 1970s, where investments in sustainability were perceived as a mere expense that subtracted profits from shareholders (Clotfelter, 1985; Friedman, 1970; Navarro, 1988).

Nowadays, the literature that analyses the reactions of market participants to corporate information regarding sustainability (sustainability reports, press releases, inclusion in sustainable rankings) is still extensive. However, the results of these studies do not show agreement on their conclusions because their samples are usually small, and they do not analyse all the information available and are mainly hand picking (Capelle-Blanchard and Petit, 2019).

Another explanation for the lack of consensus, as Renneboog (2008) assures, is little scientific evidence that the investor makes decisions based on factors not related to financial performance. However, according to Unruh et al. (2016), 60% of investors associate corporate sustainability with lower risk and lower capital costs for companies. Investors often correlate responsible behaviour and corporate stability. When companies face accusations of irresponsible behaviour, it can cause them to lose their reputation or even value in the company. Therefore, investors prefer to invest in reputable companies, as they consider them less vulnerable to negative news. Investors in these companies may justify bad news from a reputable company, as an isolated incident rather than systematic misbehaviour (Aouadi and Marsat, 2016; Flammer, 2013; Oberndorfer et al., 2013).

This study analyses sustainability news worldwide because it is an excellent thermometer to understand the investor's narrative on sustainability. According to Tetlock (2014), the media serve as providers of information between companies and investors, and significantly shape their expectations. Behavioural finance studies argue that investors affected by their cognitive bias cannot assimilate all information and act rationally and overreact to negative news (Olsen, 1998; Shleifer and Vishny, 1997; Tetlock, 2007). Shiller (2019) argues that news can expand like a pandemic and cause significant economic events, including movement in stock markets. This study aims to complement these studies and answer if negative sustainability news also has more significant reactions on the stock market and if they can go viral (Shiller, 2019).

Recent studies that analyse news about sustainability or ESG are scarce. That is why we want to contribute to expanding the existing literature. First, it is worth mentioning Flammer (2013), where 117 positive and 156 negative sustainability news from the Wall Street Journal are studied from 1980 to 2009 for all US-listed companies. Its results find negative abnormal returns after the publication of negative news and positive after positive news. As previously researchers (Aouadi and Marsat 2016; Oberndorfer et al. 2013), Flammer (2013) also concludes that companies with strong environmental performance react less negatively to negative news. Krüger (2015) studies 2116 ESG news from 725 companies during 2001–2007. The results confirm that negative news causes the share price to fall, while in the case of positive news, the reaction only occurs when the relationship with stakeholders is poor. He also concludes that reactions are more significant when the news uses legal solid and economic language. The most recent paper is Capelle-Blanchard and Petit (2019). It analyses more than 33,000 ESG news from the world's largest listed multinationals between 2002 and 2010; they conclude that market participants do not react to corporate advertisements by companies nor NGO reports. However, they do it with the news, especially the negative ones. As Flammer (2013), Capelle-Blanchard and Petit (2019) also confirm that having an ESG reputation protects against potential shareholder losses due to bad press. For this reason, they affirm that there may be an incentive for companies to publish their positive ESG news to protect themselves from the

negative impacts of contrary news. Finally, finding similar conclusions, Ahsan, and Qureshi (2021) find that the European firms that disclose environmental and social information increase their reputation.

10.3. Materials

The sample of this chapter contains all the news published digitally worldwide, which mentions the leading European energy companies and a combination of sustainability keywords, as displayed in Table 6; for example: ‘Acea SP’ + ‘gas’ + ‘nitrogen oxides.’ The analysis period was from January 2017 to December 2019.

Table 6, Data dictionary Europe

Companies	Type of energy	Environmental consequences
Acea Sp	Gas	Nitrogen
AkerSolutions	Fossil Fuels	Phosphorus
CairnIndia	Renewables	Carbon dioxide
DCC	Nuclear	CO2
EON SE	Coal	Methane
EDF	Solar	Ozone
Enagas	Hydro	Pollution
Engie	Wind	Waste
Eni	Biomass	Plastic
Gruppa Lotos	Geothermal	Footprint
Hellenic Petroleum	Marine	Aerosol
Hera	Tidal	Global warming
Motor Oil Hellas	Petrochemical	Emissions
National Grid	Petrol	Greenhouse gas
Neste Oyj	Petroleum	Air quality
Lukoil	Ethanol	Sea level
OMV AG		Climate change
Orsted		Extreme weather
Pennon Group		Natural resources
Petrofac		Biodiversity
PKN ORLEN		Toxic
Repsol		Extinction
Rosneft		Nitrogen cycle
Royal Dutch Shell		Ocean acidification
Rubis		Land use
RWE		Fresh water
Saipem		Depletion
Saras		Chemical Pollution
Siemens Gamesa		Overexploitation
Snam		Sustainability
Tecnicas Reunidas		Ecosystem
Tullow Oil		
Tupras		
Vallourec		
Vestas		
Enel		

The databases used:

Thomson Reuters Top 100 Global Energy Leaders Ranking 2019 for European energy companies, GDELT (The Global Database of Events, Language, and Tone) for news, and Yahoo Finance for financial data

10.4. Methods

10.4.1. News Analysis Methodology

For downloading, cleaning, and analysing all global news, we developed a Python code that contains a combination of the data dictionary keywords, creating more than 28,000 different GDELT queries. This news was segmented using natural language processing techniques (GDELT Global Knowledge Graph [GKG] Version 2.0) based on the tone of the news (positive, negative, or neutral) and volume intensity (the combination of the number of times the news is read and its coverage).

Accordingly, we identified the 'Big news,' or the high-volume news, when volume intensity was above two standard deviations from the mean. Two standard deviations above the mean represent between 2.5% and 5% of the total sample, thus guaranteeing that we are analysing the tail of the total distribution, which translates into the analysis of the news with the highest volume intensity. Finally, 'Big News' are the events in the event study

10.4.2. Event Study Methodology, Expected Return Models and Significance Analysis

We used the event study methodology to measure the economic impact of the 'Big News'. Assuming that financial markets are semi-strongly efficient, prices should react immediately to the news and not show any unusual behaviour before or after the announcement (Fama, 1970).

The event studies were defined as a combination of energy, environmental consequences, tone, and the five expected return models, resulting in 7,425 event studies. Finally, 4,026 were used, as they had sufficient data (news). Regarding the abnormal volatilities (AV), we performed single-day test statistics and 585 event studies segmented by tone. The average number of events was 174.

Following Bartholdy, Olson and Peare (2007), event studies with less than 50 events were excluded to provide an acceptable size and power in the statistics results. This work followed the methodology of Brown and Warner (1985), with the event day being the day of publication of the 'Big News'. Previous finance research concluded that capital markets reveal all possible information about companies in their stock prices. Thus, the event study methodology can analyse how a singular event alternates the company's forecasts by quantifying its impact on its stock price. Among the scientific literature, this type of analysis is commonly performed using stock returns. This study examines the returns and volatilities.

According to MacKinlay (1997), to determine the lead of events to analyse the cumulative average abnormal returns (CAAR), the following characteristics should be considered:

- Day of the event: This is the day the news is published. If various news items explain the same content within a 15-day window, the news item with the highest volume intensity index will be used as the event date.
- Event window: The event window was [-7, 7]. Calculating the accumulated abnormal returns in 15 days can determine the variation or abnormal return that sustainability news can cause to the companies. The window is so wide that it collects all the information emitted by different media, explaining the same content.
- Estimation window: A 100-day pre-period was considered for each event described in the previous section.
- Expected return models: The models used for CAAR included: market model, market adjusted, comparison period mean adjusted, generalised autoregressive conditional heteroscedasticity (GARCH), and exponential generalised autoregressive conditional heteroscedasticity (EGARCH).

-Market model (mm), the most used analysis for the event study methodology. This model looks at the actual returns of a baseline reference market and tracks the correlation of a company's stock with the baseline. Equation (1) and (2) specifies the model. The abnormal return on a particular day, $AR_{it,}$ in the event window describes the difference between the actual stock return, R_{it}, on day t, and the expected return, which is foretold based on two facts; the average relationship between the firm's stock and its reference market (expressed by the α and β parameters), and the actual reference market's return, R_{mt}.

$$R_{it} = \alpha_i + \beta_i \cdot R_{mt} + \varepsilon_{it}, \quad (1) \qquad \text{then} \quad AR_{it} = R_{it} - (\alpha_i + \beta_i \cdot R_{mt}). \quad (2)$$

-Market adjusted (mam), model widely used to control the event's possible effects, the publication of the sustainability news in this case, in the stock market. In the market adjusted model, the observed return of the market on day t R_{mt} is subtracted from the return R_{it} of the observation i on day t. We get for the abnormal return:

$$AR_{it} = R_{it} - R_{mt}. \quad (3)$$

-Comparison Period Mean Adjusted Model (cpmam), the abnormal return in the event window is the return of observation i on day t minus the average return of the observation i in the estimation window:

$$AR_{it} = R_{it} - \bar{R}_i, \quad (4), \text{ where } \bar{R}_i = \frac{1}{T_1 - T_0} \sum_{t \in [T_0, T_1]} R_{it}. \quad (5)$$

-Market Model GARCH error estimation (garch), uses a single factor market model with GARCH (1, 1) errors estimated, specifically:

$$R_{it} = c_i + \beta_i R_{mt} + \gamma_i D_{it} + \varepsilon_{it}, \quad (6)$$

The conditional variance (Bollerslev 1986) may be written as:

$$\sigma_{it}^2 = \alpha_{i0} + \alpha_{i1} \varepsilon_{i(t-1)}^2 + \lambda_i \sigma_{i(t-1)}^2 + \delta_i D_{it}. \quad (7)$$

where D_{it} is a dummy variable which takes 1 on the disclosure day t and 0 otherwise for firm i; σ_{it}^2 and ε_{it} are the volatility and the errors of the firm i. Also, R_{it} is the return of firm i and R_{mt} is the return of the reference market m both on day t. Equations (6) and (7) represent the mean and time-varying volatility functions respectively. The abnormal returns and abnormal volatility caused by the publication of sustainability news are measured by γ and δ_i for firm i. Parameters are estimated by maximum likelihood (a non-linear solver is used for the optimization problem).

- Market Model EGARCH error estimation (egarch), Nelson (1991) proposed the EGARCH model to include the asymmetric effect of changes in the prices of an asset on its volatility. The Garch (1,1) model does not account for any asymmetry that may arise from the negative and positive moves of the market or as it is usually called, the leverage effect. To solve this, the EGARCH model applies a logarithmic conditional variance. Equation (8) is the conditional variance of the EGARCH (1,1) model:

$$ln(\sigma_{it}^2) = \omega_i + \beta_i ln(\sigma_{i(t-1)}^2) + \alpha_i \left| \frac{\varepsilon_{i(t-1)}}{\sigma_{i(t-1)}} \right| + \gamma_i \frac{\varepsilon_{i(t-1)}}{\alpha_{i(t-1)}}. \quad (8)$$

where ω corresponds to a constant , β is the now logarithmic GARCH term, α is the ARCH term that no longer has to be positive. The γ is the so-called leverage term; if is significant and different from zero there will exist asymmetry in estimation period. The σ is the standard deviation.

The expected returns have been obtained from the estimated coefficients for each company and event, using a pre-event period of 100 days, with day 0 being the day of publication of the Big News. Given the nature of the information examined, it is interesting to analyze the market reaction around the event date, since there could be an anticipated reaction due to possible leaks of the information or also a delayed reaction. To study these possible effects, the period [−7, +7] has been used as the event window.

Cumulative abnormal returns (CAR_{it}), refers to the sum of abnormal returns (AR_{it}) over a given period of time, the event window [−7, +7].

$$CAR_{it} = \sum_{t=t1}^{t2} AR_i. \quad (9)$$

Average Abnormal Returns (AAR_t) aggregates the abnormal returns (AR_{it}) for all n stocks to find the average abnormal return at each time t.

$$AAR_t = \frac{1}{n} \sum_{i=1}^{n} AR_{it}. \quad (10)$$

Cumulative Average Abnormal Return ($CAAR_t$), illustrated in equation (11) adds the average abnormal daily return for the intervals within the event window , [−7, +7].

$$CAAR_t = \sum_{t=t1}^{t2} AAR_t. \quad (11)$$

The hypotheses of this study have been analysed using a parametric test, the skewness-adjusted t-test (Hall, 1992) correcting possibly skewed abnormal returns distributions. Recalling the (unbiased) cross-sectional sample variance as:

$$\sigma(CAAR_t) = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(CAR_{it} - CAAR_t)^2}. \quad (12)$$

Then the skewness estimation focused on averaged abnormal returns is specified by:

$$t_{skew} = \sqrt{n}(S + \frac{1}{3}\hat{\gamma}S^2 + \frac{1}{6n}\hat{\gamma}), \quad (13)$$

$$\hat{\gamma} = \frac{\sum_{i=1}^{n}(CAR_{it} - CAAR_t)}{n\sigma(CAAR_t)^3}. \text{ where } (14),$$

$$S = \frac{CAAR_t}{\sigma(CAAR_t)}. \quad (15)$$

Where $\hat{\gamma}$ is the estimate of the coefficient of skewness and $\sqrt{n}S$ is the conventional t-statistics.

Once the abnormal returns are calculated, is needed to determine if the deviation from the normal return is a statistically significant. For that, a skewness-adjusted t-test is applied with the hypothesis test defined as:

The abnormal returns cannot be distinguished from zero

H_O: CAAR = zero

The abnormal returns can be distinguished from zero

H_1: CAAR ≠ zero

The decision is to reject H_0 if $t_{skew} > t_{critical}$ or p-value < 0.05. This means that the value is statistically significantly different from zero with a significance level of 5%.

This means that if the t_{skew} is greater than 1.96 or minor than -1.96 we reject. If we do not reject because the is less than 1.96 indicates the results are not statistically different from zero.

AV Methodology:

As mentioned above, we have also carried out an event study analyzing volatility.

A single-day test statistic was performed testing the effects on the mean and the conditional volatility function on the time series simultaneously (Balaban and Constantinous 2006). The time series is utilised as a whole, so there is no need of an event window. We used the market model with GARCH errors (Bollerslev 1986).

$$R_{it} = c_i + \beta_i R_{mt} + \gamma_i D_{it} + \varepsilon_{it}, \quad (16)$$

The conditional variance can be written like:

$$\sigma_{it}^2 = \alpha_{i0} + \alpha_{i1}\varepsilon_{i(t-1)}^2 + \lambda_i\sigma_{i(t-1)}^2 + \delta_i D_{it}. \quad (17)$$

where D_{it} is a dummy variable which takes 1 on the disclosure day *t* and 0 otherwise for firm *i*; σ_{it}^2 and ε_{it} are the volatility and the errors of firm *i*. Also, R_{it} is the return of firm *i* and R_{mt} is

the return of the reference market *m* both on day *t*. Equations (16) and (17) represent the mean and time-varying volatility functions respectively. The abnormal returns and abnormal volatility caused by the publication of sustainability news are measured by γ and δ_i for firm *i*.

We calculate another cross-sectional t-statistic

To test whether the conditional volatility on announcement day is different from the other days across the firms we used the parametric test: Average of Cross-Sectional-Corrected-Vy-t-Test. This statistic standardizes δˆi by the standard deviation of daily conditional volatility of firm i during the entire period:

$$t(\hat{\delta}) = \left\{ \sum_{i=1}^{n} S_{i/n} \right\} / \left\{ [1/n(n-1)] \sum_{i=1}^{n} \left[S_i - \sum_{j=1}^{n} S_j/n \right]^2 \right\}^{0.5} \quad (18)$$

Where $S_i = \hat{\delta}/\hat{\sigma}_{i,0}$ represents the adjustment of $\hat{\delta}_i$ by the estimated volatility of firm *I* on the day of the publication of the sustainability news.

To test if the Abnormal Volatilities are statistically significance, we used the Cross-Sectional-Corrected-Vy-t-Test with a significance level of 5% as performed with the Abnormal Returns.

The event studies were carried out in the Python software environment, using the 'EventStudy' package by Schimmer, Levchenko, and Müller (2014) hosted on RapidAPI.

10.5. Results

The result section is divided into two parts: first, the CAAR results are presented, followed by the AV.

The composition of companies in the sample is strongly linked to fossil fuels, such that the results reflect investors' opinions in this sort of industry.

10.5.1. Cumulative Average Abnormal Returns (CAAR)

The results are shown aggregated in the following section.

Figure 10, Number of event studies and CAAR results

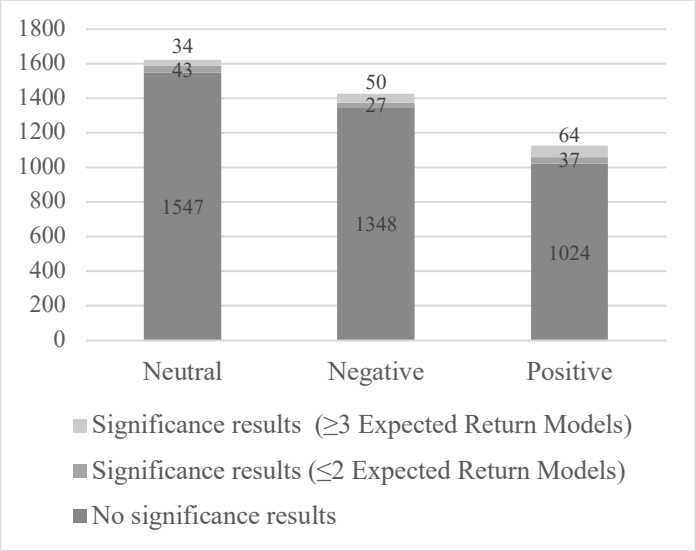

Figure 10 summarizes the results of the 4,026 event studies, differentiated by the tone of the news. The bar graph analyses whether the event studies' results are significant or not.

The first conclusion is that regardless of the tone of the news, most of them did not impact the behaviour of investors. Of the 4,026 event studies, only 255 were statistically significant with any of the five expected return models, and only 148 had statistically significant results refuted by three or more models. There are several reasons for this. First, as Shiller (2019) demonstrated, only some news stories go viral, and it is challenging to find out which ones and why. Second, the data dictionary spans many words that encompass news items that could not interest the investors. Figure 10 shows that neutral news event studies were almost 30% more abundant than positive news event studies and 13% more frequent than negative news events. However, the number of significant event studies on positive news was 35% higher than negative and neutral news.

Table 7 shows the average statistics for all event studies with significant results with three or more expected return models. This table's main conclusion is that negative news tended to cause negative reactions in investors, causing a drop in stock prices. This finding aligns with the negativity theory bias. Bad has a more significant impact than good, around four times more, in this case, three times more. Tierney and Baumesiter (2019) and Corns (2018) describe it as a proven empirically psychological principle that affects humans in everyday life situations. In addition, specific finance studies argue that investors affected by cognitive bias overreact to negative news (Olsen, 1998; Shleifer and Vishny, 1997; Tetlock, 2007).

However, positive, and neutral news tended to compensate for their impact when calculating averages, as the reading of positive and neutral news for investors is not homogeneous.

Table 7, CAAR Statistics summary from all significant event studies

Tone	Event window	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average sample size
Negative	(-7,7)	-1,1494	-0,0079	0,0182	116
Neutral	(-7,7)	0,3018	0,0026	0,0217	142
Positive	(-7,7)	-0,3904	-0,0016	0,0168	107

Table 8 summarizes the results of the 4,024 event studies, differentiated by the tone of the news and aggregated by type of energy. The event window was [-7, 7].

The table shows that there is more negative and neutral news than positive. However, renewable energy news and positive tone news were more frequently statistically significant. This finding refutes the negative bias theory, stating that humans focus more strongly on negative news than positive. It is also important to stress that significant positive news about fossil fuels was more abundant than negative or neutral news, indicating that positive sustainability narrative benefits more than negative news penalising them (Capelle-Blanchard and Petit, 2019), a clear incentive for greenwashing.

Table 8, CAAR event studies' summary segmented by type of energy

Type of energy	Negative tone news		Neutral tone news		Positive tone news	
	No statistical significance	Statistical significance	No statistical significance	Statistical significance	No statistical significance	Statistical significance
Renewables	723	29	872	27	566	26
Fossil fuels	511	15	553	4	383	26
Nuclear	114	6	122	3	75	12

Table 9 presents the average of all statistically significant abnormal return event studies aggregated by type of energy; in addition, the average skewness corrected T, average CAAR value, and average P-value. The event window was [-7, 7].

This table shows that the statistically significant results correspond to the neutral news on fossil and nuclear energies, with a positive sign, implying an increase in the share´s profitability. Additionally, we find significance in positive nuclear news, with a negative sign indicating a dropped in share prices.

Even without finding statistical significance, the news on renewable energies always obtained results with a negative sign. On the other hand, fossil energies obtain more significant reactions when they are neutral and positive. Nuclear energies showed statistically significant positive reactions with

neutral news and negative with positive news, indicating that their narrative was different for all investors.

The news with a positive tone on sustainability caused more frequent negative reactions in the stock market, except when they covered fossil fuel companies.

Regarding the positive reactions, the investors valued positive news about fossil fuel companies, sending a signal that their efforts to appear greener are valued.

Table 9, CAAR for significant queries aggregated by type of energy

	Negative			Neutral			Positive		
Type of energy	Average of Skewness Corrected T	Average of CAAR Value	Average of P value	Average of Skewness Corrected T	Average of CAAR Value	Average of P value	Average of Skewness Corrected T	Average of CAAR Value	Average of P value
Renewables	-0,8493	-0,0060	0,0231	-0,4885	-0,0033	0,0253	-1,4978	-0,0084	0,0154
Fossil fuels	-1,1284	-0,0081	0,0182	2,5198*	0,0253	0,0227	1,4710	0,0100	0,0200
Nuclear	0,0160	-0,0013	0,0179	2,9321*	0,0126	0,0044	-3,2168*	-0,0201	0,0106

*Statistical significance

The CAAR results indicated no consensus among investors concerning the sustainability narrative, probably because of the incentives for the companies in the sample, highly linked to fossil fuels. News that GDELT algorithms classify as positive tone can be interpreted by investors as negative for their economic interests and vice versa. It should also be noted that CAAR reactions could compensate when there is not an aligned narrative.

To obtain a clear view of the shareholder's opinion, the AVs were studied. The AV values are squared, so unlike the CAARs, they cannot be offset.

10.5.2. Abnormal Volatilities (AV)

Figure 11 summarizes the impact of all AV event studies. In contrast to CAARs, the proportion of event studies with statistically significant results was much higher. For example, for negative news, 39% significant results were found, 45% on neutral news, and 36% for positive news. On CAARs, the statistically significant proportion of event studies did not reach 5% of the total. These results indicate, as suspected, that investors were not sharing the sustainability narrative. Therefore, CAAR results were counterbalanced.

Figure 11, Number of event studies and AV results

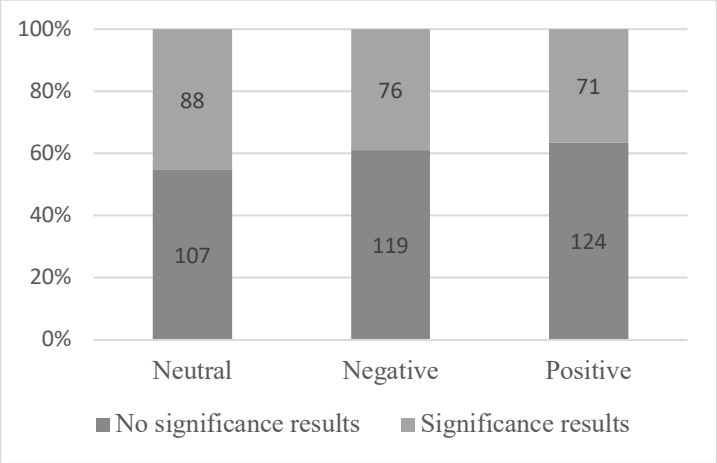

Table 10 shows the average statistics for all the event studies with significant results. It corroborates that the CAAR results were compensated. Because, when working with absolute values, there was greater volatility in the days of sustainability news publication.

Table 10, AV Statistics summary from all significant event studies

Tone	Average of Cross-Sectional-Corrected-Vy-t-Test	Average of p_val
Negative	1,9451	0,1178
Neutral	2,0545*	0,1000
Positive	1,9040	0,1266

*Statistical significance

Table 11 summarises all event studies segmented by energy type. Remarkably, the most frequent news and those with more significant results were renewable energies, regardless of the tone. The same happened in Table 8, where CAARs were analysed. The differences from Table 8 were found in nuclear energy. Although the number of nuclear energy news was small, it was the one that had the higher significant results, where more than half of the event studies performed were statistically significant.

Table 11, AV event studies' summary segmented by type of energy

Type of energy	Negative tone news		Neutral tone news		Positive tone news	
	No statistical significance	Statistical significance	No statistical significance	Statistical significance	No statistical significance	Statistical significance
Renewables	67	39	64	43	73	34
Fossil fuels	43	27	34	35	41	28
Nuclear	9	10	9	10	10	9

Table 12 highlights the average of all statistically significant abnormal volatile event studies aggregated by type of energy. In addition, the table details the average of the Cross-Sectional-Corrected-Vy-t-Test and the average of p-value. This table shows that all types of energies and news tones had a statistically significant impact, in contrast with Table 8, where CAAR results were not.

Table 12, AV for significant queries aggregated by type of energy

Type of energy	Negative		Neutral		Positive	
	Average of Cross-Sectional-Corrected-Vy-t-Test	Average of P value	Average of Cross-Sectional-Corrected-Vy-t-Test	Average of P value	Average of Cross-Sectional-Corrected-Vy-t-Test	Average of P value
Renewables	2,5361 *	0,0230	2,7903 *	0,0168	2,6560 *	0,0202
Fossil fuels	2,8404 *	0,0135	2,6904 *	0,0164	2,6833 *	0,0163
Nuclear	2,4001 *	0,0141	2,5860 *	0,0230	1,9867 *	0,0250

*Statistical significance

10.6. Discussion

This study confirms that sustainability news is followed by the European energy companies' investors and affects the stock market. However, there is no shareholder consensus on their narrative, indicating that while some value positively the companies' efforts to be more sustainable, others penalize it. These results align with Elmalt, Igan and Kirki (2021), where they confirm how CO2 emissions are not being reduced even when there are more companies than ever claiming to be sustainable. If all

investors do not share incentives, and it remains profitable to invest in high polluters, no progress can be made towards a green transition.

These results are of critical importance for policymakers, who must, through regulation, change the investors' narrative towards decarbonization. To do this, we propose 1) Standard and mandatory sustainability audit for companies to increase transparency and accountability, 2) increase CO2 dividend to reduce pollution incentives (Akerlof et al. 2019) and 3) increase the pressure on fake news, media independence must prevail, and fact-based information must be guaranteed.

The limitations of this research are the classics of the event study methodology: First, the abnormal returns cannot entirely be the result of the market reaction to the sample's sustainability news, as other events cannot be isolated. Second, it is difficult to determine precise estimation periods. If we do not take a long window event, the risk is not to catch the real media repercussion, and at the same time, the confounding effect with other events can occur. The data dictionary should also be highlighted as a limitation, as it could be missing keywords to make the news search more efficient.

10.7. Conclusions

The objective of this research was to analyse the impact on the stock market capitalisation of sustainability news for leading European energy companies. This research intended to capture the average shareholder's reactions to companies' sustainability narratives and the consequences on shareholder value leveraging global news data.

We identified "Big News" as high impact news, publicly available at GDELT from January 2017 to December 2019, mentioning a combination of terms (Table 6) that includes: the sample companies, type of energy generation, environmental consequences, and the news' tone. Then, using the event study methodology, we analysed how investors value sustainability news and companies' impact on getting good or bad press. It is remarkable the magnitude of the study. We identified 279,546 news events and conducted 4,026 event studies.

This study analysed CAARs and AVs. However, due to multiple news events and the conflicting interests at the energy companies of the sample, mainly fossil fuel producers, the positive and negative CAAR, could cancel each other. Consequently, a volatility study was conducted, which answered this potential problem by studying absolute values.

The main contribution of this investigation to the existing scientific literature is the confirmation that sustainability events got viral, creating a narrative that impacts shareholder value significantly. Nevertheless, the ratio of significant events is much higher in terms of AV than CAAR, showing no shareholder consensus about the narrative.

As Tetlock (2007) argued, negative news impacts the market around three times more than positive news (Table 7) with CAAR, while in terms of AV are very similar (Table 10).

Ergo, sustainability is on the investors' agenda, as AV results show. All types of energies and all tones have a high statistically significant impact, and all of them have very similar magnitudes (Table 12).

In terms of the statistically significant CAAR, investors show consensus increasing the stock market value when neutral, fossil, and nuclear events are released. In contrast, they decrease when positive/nuclear events take place. This result confirms the impact of the European denuclearisation narrative after the Chernobyl disaster in 1986.

The number of news articles analysed, and the number of event studies conducted, is much higher than in any previous research, allowing robust results to be obtained. In addition, to further guarantee the robustness of the study, results were only considered significant with a consensus of more than three out of five expected return models.

To ensure and facilitate replicability, all the databases used are open source: GDELT for the news and Yahoo Finance for the market data.

Finally, future research based on this study should analyse other markets to compare reactions and to understand possible cultural biases. It will also be interesting to identify which news items have had the most impact and study these cases individually, see how they have affected the different industries, fossil fuels, nuclear and renewables, and identify the conflicts of interest found in this research.

11. Chapter three

A multi-study approach using event studies to analyze American energy companies' investors' reactions to sustainability news.

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11.1. Introduction

The environmental, social and governance (ESG) concept has gained momentum over the last decade. In addition to citizens, media, and governments, global pressure has compelled several companies to establish new corporate objectives that are more respectful to the environment today and to adopt sustainable corporate practices (Gillet-Monjarret, 2015; Mallin, 2008; Meixell and Luoma, 2015; Muralidharan, Rejón-Guardia and Xue, 2016; Rentizelas et al., 2020).

In the past, commitments to the environment were seen by investors as merely an expense or an unproductive cost (Cañón-de-Francia and Garcés-Ayerbe,, 2009; Oberndorfer et al., 2013). However, currently, the message that is getting through is that the greater the commitment to ESG, the greater the long-term profitability (Ashwin Kumar et al., 2016; Flammer, 2013; Friede, Busch, and Bassen, 2015; Gibson, Krueger, and Mitali, 2020; Maiti, 2020; Muhmad and Muhamad, 2020; Sharma et al., 2021).

Therefore, investors' interest in companies committed to ESG has been increasing (Andersson, Bolton, and Samama, 2016; Pinney, Lawrence, and Lau, 2019; Ruggie and Middleton, 2019; Unruh et al. 2016), not just because of greater profitability, but because of an ecological and social conscience (Barnett and Salomon, 2006; Glac, 2012; Jo, 2003). Globally, sustainable investment assets increased by 34% from 2016 to 2018, reaching $30.7 trillion (Global Sustainable Investment Alliance [GSIA], 2018). Consequently, the incentives to companies to be or to appear to be sustainable is increasing (Flammer, 2013).

However, in the United States (US)—the world's most active stock market—investments in ESG are lower than in Europe. In 2018, the US had $11.9 trillion invested in sustainable assets, accounting for only 25% of the total; meanwhile, European investments amounted to $14 trillion, accounting for 49% (GSIA, 2018). This difference in investment proportion is due to the significant dependence on fossil fuels in the American market—80% of the energy consumed comes from oil, coal, and natural gas, all of which are fossil fuels (Capuano, 2018). Another influential factor has been US regulations on sustainability, which moved into a phase of disinterest and even discouraging positions under the Trump administration.

However, this trend is changing with the new administration, with the return to the Paris agreement and the increasing presence of ESG companies in the stock market. About eight in ten US investors are interested in sustainable investments, with a half of them investing in at least one sustainable asset (Alliance, Global Sustainable Investment, 2019). However, even though more companies and investors than ever are claiming to be sustainable, CO2 emissions have been rising unabated (Elmalt, Igan, and Kirki, 2021). This indicates that first, the sustainability narrative is not aligned with practice, and that second, there are clear incentives for greenwashing by companies.

Consequently, given the relevance that sustainability has acquired for investors and the unprecedented access to information that we currently have, it is highly probable that investors will react to sustainability news.

The motivation is to understand the sustainability narrative of the US energy companies' investors by exploring the following questions: Do investors follow sustainability news? Do they respond to negative sustainability news more than to positive or neutral? What type of energy makes the market more volatile? Is there a consensus about renewable energy? Is nuclear power still on the investors' agenda? Is greenwashing profitable?

This research uses the event study methodology to analyze how the investors of leading US energy companies[1] react to viral sustainability news. We downloaded all the high impact news published digitally[2] worldwide from January 2017 to December 2019. The news was extracted from Global Database GDELT and grouped by tone[3], type of energy, and environmental consequence, and each combination launched an event study.

The contributions of this study are many; we identified that positive news about fossil fuels more positively impacted the stock market than positive renewable energy news. These results provide empirical evidence for greenwashing by businesses.

Another contribution is the magnitude of the study and the news segmentation by type of energy and tone. To date, no study has analyzed US company investors' reactions to sustainability news at this level of detail and scale. By analyzing the different energy types and tones in the news, it is possible to understand thoroughly the preferences and biases of the investors.

The remainder of the article is organized as follows:

The following section analyzes the related literature, emphasizing how investors value sustainability and news through stock market analysis. Thereafter, we detail the sample and the methodology. Finally, the results, discussion and conclusions are presented.

11.2. Literature review

The third chapters aim to understand the sustainability narrative of the US energy companies' shareholders through the news. We have chosen the news media as a source of information because media has a crucial responsibility regarding variabilities in the stock market prices (Barber et al., 2009; Da, Engelberg and Gao, 2009; Oberlechner and Hocking, 2004; Tetlock, 2007).

We consider two components to analyze the related work—news and the stock market, which discusses investors' cognitive biases, and sustainability and the stock market, which addresses shareholder reactions to sustainability information.

11.2.1. News and the stock market

Behavioral finance studies argue that investors are affected by their cognitive bias and are unable to assimilate all information and act rationally, overreacting to negative news (Shleifer and Vishny, 1997; Olsen, 1998; Tetlock, 2007).

Other researchers argued that the more media attention for certain companies, the higher trading volume or volatility (McCombs and Shaw, 1972; Carroll and McCombs, 2003; Tetlock, 2007; Barber and Odean, 2009 Bushee and Miller, 2012).

Chan (2003), Li (2016), Li (2017) and Tetlock et al. (2007) found that companies whose news was negative reported lower earnings. Similarly, other researchers have analyzed how the press increasingly uses more emotional language to attract more attention, which affects the market to a greater extent (Lewis et al., 2008; Vettehen et al., 2010). Moreover, the scientific research suggests that the market is a mirror of the news rather than a variable and that it is the news that reacts to the market and not the other way around (Oberlechner and Hocking, 2004; Scheufele et al., 2011; Thompson, 2013; Strauß et al., 2016). Finally, it is worth highlighting the finding of Shiller (2019). This Nobel laureate argues that news can expand like a pandemic and cause significant economic events such as movements on the stock markets.

Based on previous literature, we seek to understand whether the investors in our sample are negatively biased and whether the stock market becomes more volatile when few sustainability news becomes viral.

11.2.2. Sustainability and the stock market

Several scientific studies have used the event study methodology to measure the connection between environmental measures and financial performance, albeit with a smaller sample size than in our study and handpicking. In general, these studies identified negative reactions from shareholders to negative environmental communication (Blacconiere and Patten, 1994; Capelle-Blancard et al., 2019; Consolandi et al., 2008; Cheung and Roca, 2013; Dasgupta, Laplane and Mamingi 2001; Farber at al., 2009; Flammer, 2013; Grand and D'Elia, 2005; Gupta and Goldar, 2005; Hamilton, 1995; Jory et al., 2015; Khanna et al., 1998; Klassen and McLaughlin, 1996; Konar and Cohen, 1997; Krüger, 2015; Marciukaityte et al., 2006) and positive reactions to positive environmental communications (Cheung et al., 2013; Chollet and Cellier, 2011; Consolandi et al., 2008; Filbeck and Gorman, 2004; Flammer, 2013; Nagayama and Takeda, 2006; Wingender and Woodroof, 1997; Yamashita et al., 1999).

Numerous studies have found positive relationships between sustainability and profitability outside of the event study methodology. The Centre for Sustainability and Excellence, n.d. It detects an apparent correlation between sustainability and financial results in North America. They find that

75% of companies with sustainability reports and high ESG ratings reported better financial results than in the period when the ESG ratings were lower.

Moreover, Yin et al. (2019) demonstrated the positive relationship between disseminating environmental information and profitability for companies that substantively address sustainability. Another critical research on the question is by Eccles et al. (2014). They investigated 180 US companies for 18 years, finding that "high sustainability companies" outperformed "low sustainability companies" both in the stock market as well as in terms of accounting performance.

Other studies that identify a positive relationship between CSR and sustainability include Orlitzky et al. (2003), Margolis and Walsh (2003), Maignan et al. (2005), Marom (2006), Wu and Shen (2013), Van Beurden and Gössling (2008), Abu Bakar and Ameer (2011), and Oeyono et al. (2011), amongst others.

However, new evidence suggests that companies with frequent good news regarding sustainability have an excellent reputation. A good reputation protects companies from possible losses in the event of bad news as the investor does not penalize them (Ahsan and Qureshi, 2021; Aouadi and Marsat 2016; Capelle-Blanchard and Petit, 2019; Flammer 2013; Oberndorfer et al. 2013). This tendency indicates a clear incentive for greenwashing.

Like the present study, Barroso del toro, Tort-Martorell and Canela (2022) analyzed the reactions of European energy companies' investors to sustainability news. They found that while sustainability news affected the stock market, there was no consensus among investors regarding renewable energy news. This indicates that the narrative was not homogeneous among the investors.

Based on these studies, we also seek to understand whether the largest US energy companies demonstrate greenwashing in the sustainability news.

11.3. Materials and Methods

11.3.1. Materials

For this study, we downloaded the publication dates of all relevant news published digitally worldwide on sustainability and the top leading American energy companies[1]. We also compiled the closing prices of the American stock markets where the companies in our sample are listed. Table 13 presents the data sources.

Table 13, Data sources United States

Companies	North American companies included in the Thomson Reuters Top 100 Global Energy Leaders Ranking 2019
News	GDELT (The Global Database of Events, Language, and Tone), package: GDELT Global Knowledge Graph (GKG) Version 2.0
Stock data	Yahoo Finance

GDELT is the largest news database in the world. It is open-source and monitors all the news published digitally across the globe in 100 different languages. Kwak and An (2016) described it as a tale of the world.

For each news article, GDELT offers the publication date, its "news volume" (combination of the number of times some news is read and its coverage) and segmentation by tone: negative, neutral, and positive. These segmentations were performed using natural language processing techniques (GDELT Global Knowledge Graph (GKG) Version 2.0).

For the tone of news, GDELT uses 51 data dictionaries, including the following popular dictionaries that have been high-lighted in the literature: "Harvard IV-4 Psychosocial Dictionary" "Harvard IV-4 Psychosocial Dictionary" (Stone et al., 1966), the "WordNet-Affect dictionary" (Strapparava et al., 2004; Valitutti and Strapparava, 2004), the "Loughran and McDonald Sentiment Word Lists dictionary" (Loughran and McDonald, 2016; Loughran and McDonald, 2011.

GDELT also offers the possibility of consolidating all the news that deal with the same topic on one date, using the date with the highest news volume. We have used this option to avoid repeating events in our event studies.

Our search method in GDELT—devised using Python programming language—is based on a combination of three terms: company name, type of energy, and environmental consequence that produced 12.172 combinations. Table 14 presents the terms.

From the each of the combinations we downloaded all the news whose news volume (the combination of the number of times the news is read and its coverage, by GDELT) was more than two standard deviations from the average of all the news. This ensures that we analyze only the tail of the distribution, focusing on the news with the most significant impact. This, result in 207,386 the high-volume news about sustainability.

We downloaded data on the date of the news, news volume, and tone from GDELT.

Table 14, News Selection criteria

USA companies*	Energy	Sustainability Keywords
Anadarko	Gas	Nitrogen
Marathon oil corp	Fossil Fuels	Phosphorus
Avangrid	Renewables	Carbon dioxide
Chevron corp	Nuclear	CO2
CMS Energy	Coal	Methane
ConocoPhillips	Solar	Ozone
ExxonMobil	Hydro	Pollution
Covia Holding	Wind	Waste
First Solar	Biomass	Plastic
Halliburton Comp	Geothermal	Footprint
Hess Corp	Marine	Aerosol
Marathon Oil Corp	Tidal	Global warming
Ni Source	Petrochemical	Emissions
Occidental Petroelum Corp	Petrol	Greenhouse gas
Philips 66	Petroleum	Air quality
Schlumberger	Ethanol	Sea level
Sempra Energy		Climate change
Sun Power		Extreme weather
Vestas		Natural resources
Enel		Biodiversity
		Toxic
		Extinction
		Nitrogen cycle
		Ocean acidification
		Land use
		Fresh water
		Depletion
		Chemical Pollution
		Overexploitation
		Sustainability
		Ecosystem

11.3.2. Methods

We applied Brown and Warner's (1985) event study methodology to conduct this study. This event study methodology has become a standard method to measure the reaction of share prices to an advertisement or event since Ball and Brown (1969) and Fama, Fisher, Jensen, and Roll (1969) introduced it. Assuming that the financial markets are semi-strongly efficient, the stock prices should immediately reflect the news information (Fama, 1970).

To examine in depth all the news downloaded from GDELT, we grouped them by tone, type of energy, and environmental consequence (for example, Positive Tone, Fossil fuel, CO2), carrying out five event studies for each of the 1,485 combinations.

We analyzed the cumulative average abnormal returns (CAAR) and abnormal volatilities (AV). In the case of CAAR, we used 1,485 combinations per five expected return models, resulting in 7,425 CAAR event studies and 1,485 Avs event studies as for AV we performed one market model.

As the first step of the event study, the day of interest and the period over which the stock prices will be studied (i.e., the event window) must be defined.

•Day of the event: The day of the event is when the news is published. If there were any news with the same content within a 15-day window, we used the dates with the highest news volume.

•Event window: The event window is [-7, 7]. The window is wide enough to collects all the information explaining the same content but disseminated by different media.

The study was conducted based on events between January 1, 2017, and December 31, 2019. The event window was defined as the period between seven days before the event and seven days after the event—a total of fourteen days. Day zero denotes the day of publication of the news. The estimation window, used to predict normal returns, was defined as the period corresponding to 100 days before the event window. Logarithmic returns were used in both windows.

Assessing the impact of the event requires a measure of abnormal performance (AR). Five expected return models were used to model the AR; significant results were accepted only if at least three out of five models confirm it. The models used are as follows: market, market-adjusted, comparison period mean-adjusted, generalised autoregressive conditional heteroscedasticity (GARCH), and exponential generalised autoregressive conditional heteroscedasticity (EGARCH) models.

- The market model (mm) is commonly used for event study analysis. This model considers the actual returns of a baseline reference market and tracks the correlation of a company's stock with the baseline. Equations (1) and (2) specify the model. The abnormal return on a particular day, ARit, in the event window describes the difference between the actual stock return, Rit, on day t, and the expected return, which is foretold based on two facts; the average relationship between the firm's stock and its reference market (expressed by the α and β parameters), and the actual reference market's return, Rmt.

$$R_{it} = \alpha_i + \beta_i \cdot R_{mt} + \varepsilon_{it}, \quad (1) \quad \text{then} \quad AR_{it} = R_{it} - (\alpha_i + \beta_i \cdot R_{mt}). \quad (2)$$

-The market-adjusted model (mam) is widely used to control the event's possible effects—in this case, the effects of the publication of sustainability news in the stock market. In the market-adjusted model, the observed return of the market on day t (Rmt) is subtracted from the return Rit for observation i on day t. Equation 3 specifies the abnormal return:

$$AR_{it} = R_{it} - R_{mt}. \quad (3)$$

-In the comparison period mean-adjusted model (cpmam), the abnormal return in the event window is the return of observation i on day t minus the average return of the observation i in the estimation window (Equations 4 and 5):

$$AR_{it} = R_{it} - \bar{R}_i, \quad (4), \text{ where } \quad \bar{R}_i = \frac{1}{T_1 - T_0} \sum_{t \in [T_0, T_1]} R_{it}. \quad (5)$$

-The market model GARCH error estimation (garch) uses a single factor market model with GARCH (1, 1) errors estimated, specifically:

$$R_{it} = c_i + \beta_i R_{mt} + \gamma_i D_{it} + \varepsilon_{it}, \quad (6)$$

The conditional variance (Bollerslev 1986) may be written as:

$$\sigma_{it}^2 = \alpha_{i0} + \alpha_{i1}\varepsilon_{i(t-1)}^2 + \lambda_i \sigma_{i(t-1)}^2 + \delta_i D_{it}. \quad (7)$$

where Dit is a dummy variable which takes 1 on the disclosure day t and 0 otherwise for firm i; and εit are the volatility and the errors of firm i, respectively. Also, Rit is the return of firm i and Rmt is the return of the reference market m, both on day t. Equations (6) and (7) represent the mean and time-varying volatility functions, respectively. The abnormal returns and abnormal volatility caused by the publication of sustainability news are measured by γ and δi for firm i. Parameters are estimated by maximum likelihood (a non-linear solver is used for the optimization problem).

-Market Model EGARCH error estimation (egarch), Nelson (1991) proposed the EGARCH model to include the asymmetric effect of changes in the prices of an asset on its volatility. The Garch (1,1) model does not account for any asymmetry that may arise from the negative and positive moves of the market or as it is usually called, the leverage effect. To solve this, the EGARCH model applies a logarithmic conditional variance. Equation (8) is the conditional variance of the EGARCH (1,1) model:

$$ln(\sigma_{it}^2) = \omega_i + \beta_i ln(\sigma_{i(t-1)}^2) + \alpha_i \left| \frac{\varepsilon_{i(t-1)}}{\sigma_{i(t-1)}} \right| + \gamma_i \frac{\varepsilon_{i(t-1)}}{\alpha_{i(t-1)}}. \quad (8)$$

where ω corresponds to a constant, β is the now logarithmic GARCH term, α is the ARCH term that no longer has to be positive. The γ is the so-called leverage term; if is significant and different from zero there will exist asymmetry in estimation period. The σ is the standard deviation.

The expected returns have been obtained from the estimated coefficients for each company and event, using a pre-event period of 100 days, with day 0 being the day of publication of the day of event. Given the nature of the information examined, it is interesting to analyze the market reaction around the event date, since there could be an anticipated reaction due to possible information leaks or also a delayed reaction. To study these possible effects, the period [−7, +7] has been used as the event window.

Cumulative abnormal returns (CARit), refers to the sum of abnormal returns (ARit) over a given period of time, the event window [−7, +7].

$$CAR_{it} = \sum_{t=t1}^{t2} AR_i. \quad (9)$$

Average Abnormal Returns (AARt) aggregates the abnormal returns (ARit) for all n stocks to find the average abnormal return at each time t.

$$AAR_t = \frac{1}{n} \sum_{i=1}^{n} AR_{it}. \quad (10)$$

Cumulative Average Abnormal Return (CAARt), illustrated in equation (10) adds the average abnormal daily return for the intervals within the event window , [−7, +7].

$$CAAR_t = \sum_{t=t1}^{t2} AAR_t. \quad (11)$$

The hypotheses of this study were analysed using a parametric test, i.e., the skewness-adjusted t-test (Hall, 1992) As documented in Fama (1965), Press (1967), Kon (1984), Gray and French (1990) and Aparicio and Estrada (2001), stock returns are not normally distributed and tend to be skewed. The authors of Pindick (1983), French, Schwert and Stambaugh (1987) and Campbell and Hentschel (1992) suggested that this is because news increases the volatility of stocks, which magnifies their returns (especially negative news). Over 50 years ago, the authors of Fama (1970) pointed out that the way investors interpret the information around them affects market efficiency.

In the case of this investigation, the returns were skewed as we performed event studies that were segmented by tone: the negative and neutral news items were negatively skewed, and the positive items were positively skewed.

The authors of Lyon, Barber, and Tsai (1999), Banik and Golan Kibria (2011) and Cojbasic and Loncar (2011) found that the skewness-adjusted t-test that was introduced by Hall (1992) performed as well as equivalent non-parametric tests, as long as the sample size was not small.

Recalling the (unbiased) cross-sectional sample variance as:

$$\sigma(CAAR_t) = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (CAR_{it} - CAAR_t)^2.} \quad (12)$$

Then the skewness estimation focused on averaged abnormal returns is specified by:

$$t_{skew} = \sqrt{n}(S + \frac{1}{3}\hat{\gamma}S^2 + \frac{1}{6n}\hat{\gamma}), \quad (13)$$

$$\hat{\gamma} = \frac{\sum_{i=1}^{n}(CAR_{it} - CAAR_t)}{n\sigma(CAAR_t)^3}. \text{ where } (14), \quad S = \frac{CAAR_t}{\sigma(CAAR_t)}. \quad (15)$$

Where $\hat{\gamma}$ is the estimate of the coefficient of skewness and $\sqrt{n}S$ is the conventional t-statistics.

Once the abnormal returns are calculated, is needed to determine if the deviation from the normal return is a statistically significant. For that, a standard t-test is applied with the hypothesis test defined as:

The abnormal returns cannot be distinguished from zero

HO: CAAR = zero

The abnormal returns can be distinguished from zero

H1: CAAR ≠ zero

The decision is to reject H0 if tskew > tcritical or p-value < 0.1. This means that the value is statistically significantly different from zero with a significance level of 5%.

This means that if the tskew is greater than 1.96 or minor than -1.96 we reject. If we do not reject because the is less than 1.96 indicates the results are not statistically different from zero.

Although the number of event studies was 7,425 (1,485 term combinations multiplied by five expected return modes), only 3,393 were analyzed because of their sample size. Event studies with less than 50 events were eliminated, as recommended by Bartholdy, Olson, and Peare (2007), to provide an adequate sample size and robustness to the statistical results.

The companies in our sample may have conflicts of interest with each other as the core business of some are fossil fuels, while others are in renewable energies; thus, we also analyzed abnormal volatilities (AV). When analyzing the returns in absolute values, we can observe reactions that were not detected by CAAR because they were compensating each other.

A single-day test statistic was performed to test the effects on the conditional volatility function on the time series (Balaban and Constantinous, 2006). The time series is utilised as a whole, and thus, there is no need of an event window. The market model with GARCH errors was used, based on Equations (6) and (7).

We calculated another cross-sectional t-statistic to test whether the conditional volatility on announcement day is different from the other days across the firms. We used the parametric test: average of cross-sectional-corrected-vy t-test. This statistic standardises by the standard deviation of firm i during the entire period:

$$t(\delta_i) = \left\{ \sum_{i=1}^{n} S_i/n \right\} / \left\{ [1/n(n-1)] \sum_{i=1}^{n} \left[S_i - \sum_{j=1}^{n} S_j/n \right]^2 \right\}^{0.5} \quad (16)$$

where $S_i = \delta_i/\hat{\sigma}_{i,0}$ represents the adjustment of δ_i by the estimated volatility of firm i on the day of the publication of the sustainability news.

Although the number of event studies was 1,485 only 708 were analyzed because of their sample size. Event studies with less than 50 events were eliminated, as recommended by Bartholdy, Olson, and Peare (2007), to provide an adequate sample size and robustness to the statistical results.

To test if the Abnormal Volatilities are statistically significance, we used the Cross-Sectional-Corrected-Vy-t-Test with a significance level of 5% as performed with the Abnormal Returns.
The event studies were carried out in the Python software environment, using the 'EventStudy' package by Schimmer, Levchenko, and Müller (2014) hosted on RapidAPI.

11.4. Results

The result section is divided into two parts: First, the CAAR results are presented, followed by the AV. All the results are presented aggregates.

11.4.1. Cumulative Average Abnormal Returns (CAAR)

Figure 12 summarises the results of the 3,393 event studies. The bar graph examines the event studies' results, differentiating if there are significant or not, and whether these results are refuted by two expected return models or less, or by three models or more. The results are aggregated by tone.

Figure 12, CAAR Event studies results summary by tone

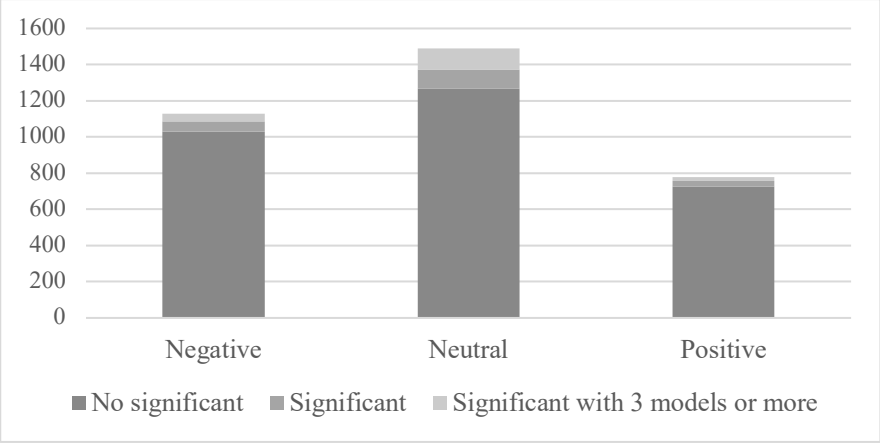

Figure 12 illustrates that most of the news did not provoke a reaction among the investors, and only 11% did, being statistically significant. If, in addition, we demand consensus of three or more expected return models, only 5% of the news in our sample impacted investors' decision-making.
Regarding the news tone, the analyzed news had a clear negative bias as negative and neutral news are higher in number than positive, representing 73% of the sample.
Similarly, the highest proportion of significant news was for neutral news, with 15% of news affecting investor investment movements, followed by negative (9%) and positive (6.5%) news. These results confirm Tetlock's (2007) assumptions that investors react more to negative news and that news media more often cover negative than positive news.
Table 15 aggregates the results of all significant event studies as confirmed by three or more expected return models. Based on Table 6, we conclude that negative and neutral news caused negative statistical significance reactions, which implies a drop in the share's prices. Meanwhile, the positive news had no statistically significant aggregated results, which indicates that the positive news event studies were compensating each other; in other words, there is no consensus among the investors.

These results align with the negativity bias that confirms that humans tend to pay more attention to negative than positive experiences or outcomes by a ratio of four to one (Tierney and Baumesiter, 2019; Corns, 2018). Thus, negativity bias could also influence investors' investment judgments.

Table 15, CAAR statistics summary from all significant event studies with three or more expected return models

New's Tone	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val
Negative	-2,4517*	-0,0168	0,0240
Neutral	-2,2449*	-0,0142	0,0175
Positive	-0,0207	0,0001	0,0255

*Statistically significant

Table 16 aggregates the results seen in Figure 12 by type of energy. Again, we can observe that the most abundant news and the highest proportion of significant news corresponded to that of renewable energies, especially those with a neutral tone, as 17% of these event studies were significant. In contrast, news about nuclear energy was less frequent and less significant.

Table 16, CAAR for significant queries with three or more expected return models aggregated by type of energy

Type of energy	Negative		Neutral		Positive	
	No Statistical significance	Statistical significance	No Statistical significance	Statistical significance	No Statistical significance	Statistical significance
Fossil fuels	425	26	468	71	319	17
Renewables	488	69	689	141	353	30
Nuclear	115	4	109	10	55	4

Table 17 reports the aggregated results for all event studies by type of energy and news tone. The main conclusion from Table 8 is that negative news, regardless of the energy type, caused statistically significant negative reactions, thus confirming the negativity bias. Similar results were observed for the neutral news. Just like negative news, all reactions to neutral news were statistically significant and negative.

Table 17, CAAR Event studies results summary aggregated by type of energy

Type of energy	Negative			Neutral			Positive		
	Average of Skewness Corrected T	Average of CAAR Value	Average of P value	Average of Skewness Corrected T	Average of CAAR Value	Average of P value	Average of Skewness Corrected T	Average of CAAR Value	Average of P value
Renewables	-2,4699*	-0,0172	0,0221	-2,4483*	-0,0152	0,0156	0,0236	0,0006	0,0222
Fossil fuels	-2,3697*	-0,0151	0,0293	-1,7788	-0,0117	0,0177	2,1176*	0,0114	0,0371
Nuclear				-2,4968*	-0,0132	0,0198			

*Statistically significant

Both positive and negative news on nuclear energy did not react to the companies' prices in our sample, although the neutral news did.

Notably, there was a non-statistically significant reaction found for positive news about renewable energy, indicating a slight lack of consensus among investors on the sustainable energy narrative.

Finally, these results highlight that the news about fossil fuels was the one that had the most significant repercussion in terms of statistical significance. This news got a reaction from the market across all news tones, and hence, it could be said that fossil fuels are still the main engine of investor attention.

The key conclusion that we can obtain from the CAAR analysis is that there was a clear negativity bias among investors in the face of sustainability news, which extended to news of a neutral tone. The news about renewable energy was the most frequent and with the highest percentage of significant event study results, indicating a clear interest in renewables among the investors. However, their narrative was not shared for positive news, suggesting that investors' interests continued to be in fossil fuels. Consequently, they might see renewables as a threat.

11.4.2. Abnormal Volatilities (AV)

We conducted a study to check if the CAAR analysis was able to detect all shareholder reactions. When working with absolute values, the AVs detect movements in the stock market that the CAARs cannot find since they are offset. Thus, statistically significant AV results will indicate that the assets analyzed have undergone significant variations in their prices—the greater the volatility, the greater

the risk and the potential losses for investors.

Figure 13, like Figure 12, shows us the number of event studies that are statistically significant. However, contrary to Figure 12, when we analyze volatilities, we find that around half of the event studies carried out are significant, regardless of the tone. These AV reactions would indicate that although in terms of CAAR, no response was observed from investors for most of the news, the AVs reveal that the market becomes more volatile in the face of sustainability news.

Figure 13, AV Event studies results summary by tone

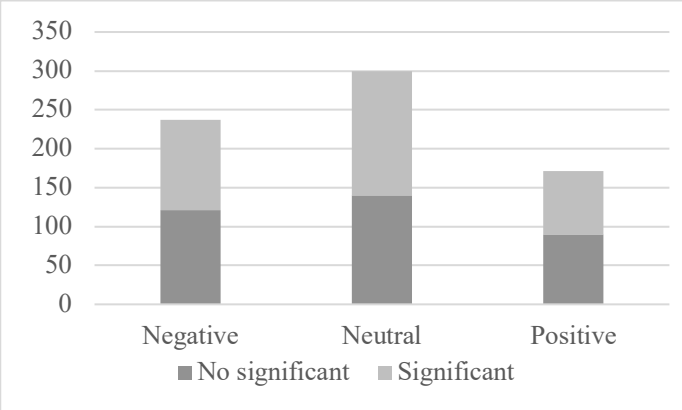

Table 18 aggregates the results of all the AV event studies by the tone of the news, and all were found to be statistically significant. In Table 6, where we analyzed the same parameters using CAARs, we found a non-significance of the positive news. The AV reaction to positive news confirms that there is no consensus on the sustainability narrative among investors. What is considered good news in terms of sustainability would raise the stock price for some, while others may consider it as negative news. Therefore, no CAAR reaction was found because the effects offset each other.

Table 18, AV Statistics summary from all significant event studies

New's Tone	Average of Cross-Sectional-Corrected-Vy-t-Test	Average of p_val
Negative	2,5984*	0,0181
Neutral	2,4758*	0,0206
Positive	2,5231*	0,0200

*Statistically significant

Table 19 shows the number of event studies with statistically significant results by type of energy. The main conclusion from this table is that the news about renewables was the most abundant, but this did not translate into a greater reaction from the stock market. The news items with the highest proportion of significant event studies were fossil fuels, followed by news on nuclear energy.

Notably, while the news on nuclear energy was rare, most of these events made the market more volatile.

Table 19, AV Event studies results summary aggregated by type of energy

Type of energy	Negative		Neutral		Positive	
	No Statistical significance	Statistical significance	No Statistical significance	Statistical significance	No Statistical significance	Statistical significance
Fossil fuels	39	52	51	57	32	42
Renewables	72	50	81	87	51	34
Nuclear	10	14	8	16	7	5

Finally, Table 20 presents the results of all the statistically significant AV event studies, aggregated by type of energy and tone of the news. As in Table 9, all the event studies analyzed were significant. This again confirms that investors follow sustainability news and make investment decisions based on it, making the stock market more volatile.

Table 20, AV for significant queries aggregated by type of energy

Type of energy	Negative		Neutral		Positive	
	Average of Cross-Sectional-Corrected-Vy-t-Test	Average of P value	Average of Cross-Sectional-Corrected-Vy-t-Test	Average of P value	Average of Cross-Sectional-Corrected-Vy-t-Test	Average of P value
Renewables	2,4264 *	0,0217	2,3692 *	0,0237	2,3526 *	0,0272
Fossil fuels	2,6500 *	0,0188	2,5443 *	0,0191	2,5156 *	0,0214
Nuclear	2,4961 *	0,0175	2,5598 *	0,0179	2,3002 *	0,0270

*Statistically significant

11.4.3. Discussion

Fossil fuels continue to have a predominant position in the American market, wherein investors are affected more by sustainability news and exhibit expected behaviour, with prices dropping for negative news and vice versa for positive ones. While the highest number of news data was about renewable energy, the investors reacted less significantly, showing a non-consensus for the sustainability narrative. This lack of consensus is visible in Table 8, where positive news about

renewables was not statistically significant; however, the positive news on renewables was significant when we analyzed AV (Table 20).

These results are similar to those found by Barroso del Toro, Tort-Martorell and Canela (2021) on European energy companies. The main difference is that in the case of Europe, the news on renewable energies found CAARs of the opposite sign to the tone of the analyzed news, indicating that the investors' interests were still highly linked to fossil fuels and saw renewable energies as a threatening competition. However, the US investors do not react to them.

These results show that the investors' interests remain in fossil fuels energy. Fossil fuel companies have a more profitable business case with positive news about their operations than renewable energy companies, thus making a case for greenwashing. Policymakers should consider these insights because if there are no economic or legal incentives to change the investors sustainability narrative in the short term, investors will focus on profit maximization and not act out of ecological awareness.

11.5. Conclusions

This study aimed to understand the sustainability narrative of the shareholders in energy companies in the US to elucidate if the investors value the companies' efforts to be sustainable or if they continue to reward business as usual to guarantee profitability.

To achieve this, we analysed all the news on sustainability, worldwide, in reference to the leading American energy companies, from 2017 to 2019, that included a combination of keywords in their articles (Table 1), including the analysed companies, energy, and environmental consequences. Moreover, we segmented all the news by tone: negative, neutral, and positive. We downloaded 207386 news items from GDELT and carried out 7425 event studies, analyzing CAARs and AVs.

By analysing the news, conducting thousands of event studies, and segmenting them by energy type and tone of the news, we were able to identify the biases of the US energy shareholders. Our contribution to existing literature is to affirm that all shareholders do not share the sustainability narrative and that fossil energies continue to be rewarded, indicating a clear incentive for greenwashing. We also confirm the negativity bias.

After analysing the CAARs and AVs, we can draw several conclusions. The main conclusion is that negative and neutral news were the most abundant and influenced the stock market downside, showing a clear negative bias. Furthermore, this negative bias was observed for all types of energy. The results also highlight that the news on renewables was the most frequent, with the most significant event studies; however, the analysis using CAARs revealed how the results on positive news are offset, indicating a non-consensus of shareholders, which in turn was supported by the AV analysis. Ultimately, we identified that positive news about fossil fuels positively impacts the market to a greater extent than positive renewable energy news. This provides the empirical evidence for the practice of greenwashing by businesses.

This research faced the classic limitation of the event study methodology. Primarily, the CAARs cannot exclusively be the consequence of the sustainability news. Subsequently, determining a precise estimation period is problematic; with long windows, while the confounding effect with other events can occur, there is a possibility of not catching the real media repercussion with shorter windows. Moreover, the data sources could have omitted keywords to make the news search more accurate.

Future directions of this study should focus exclusively on renewable energy companies to analyse whether shareholders interested in renewables have a standard sustainability narrative and overreact to negative news. It would also be very enriching to the current literature to compare the reactions of the shareholders of the countries with current carbon taxes and those without, to see if their narrative towards sustainability changes and makes them more demanding. Finally, another line of research could focus on the event study methodology using the results of this research to analyse which expected return model behaves more adequately and accept or reject the hypothesis that the market model behaves as good as the complex ones.

12. Chapter four

Comparing the Impacts of Sustainability Narratives on American and European Energy Investors: A Multi-Event Study Analysing Reactions to News Before and during COVID-19.

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12.1. Introduction

Investments in sustainability, popularly known as ethical, responsible, environ-mental, social and governance (ESG) investments, have not stopped growing over the last decade (Pinney, Laurence and Lou, 2019; Ruggie and Middleton, 2019).

Investors are no longer just looking for profitability, they also want to be part of the solution to the challenges facing society (climate change, poverty, inequality, social exclusion, etc.), meaning that they also invest in social and ecological awareness (Renneboog, Horst and Zhang, 2008; Glac, 2012; Barnett and Salomon, 2006).

ESG investments at the beginning of 2020 represented USD 35.3 trillion globally, which showed an increase of 15% over the last two years (2018–2020) and 55% since 2016 and represented 35.9% of total assets under management. In terms of the territories analysed in this paper, European ESG investments represented 41.6% of the total ESG investments and those from the USA represented 33.2% (Alliance, Global Sustainable Investment, 2020).

However, the 2021 Intergovernmental Panel on Climate Change (IPCC) warned that even in the best scenarios, it would not reach the objectives of the Paris agreement and that we are continuing on the trajectory of +3 °C, which is far from the commitment made in Paris (+1.5 °C) and places biodiversity and humanity at serious risk.

Moreover, to further complicate ecological transitions, the COVID-19 pandemic began in 2020, which became the year of involuntary life changes.

COVID-19 has shown that societies can act with necessary force when required, but regulations and political will are needed. To confront COVID-19, governments worked quickly and in unison to limit or prohibit social and economic activities, even in the face of enormous economic impacts. As a result, during the first quarter of 2020, the S&P 500 Index plummeted 34%.

COVID-19 has highlighted the fragility of our global economy and societies (EEA, 2020c). However, although nitrogen dioxide (NO2) concentrations reduced in several cities by up to 60% compared to 2019 (EEA, 2020c), and house gas emissions (GHC) decreased by 10% in Europe (EEA, 2021 C) and 11% in the USA (EPA, 2021), during the first half of 2020, the post-COVID-19 data are not encouraging. With the return of social and economic activities, the concentrations of airborne pollutants have returned to pre-pandemic levels (EEA, 2020d).

Global governments wanted to stimulate their economies using economic stimulus plans, which were strongly restricted during the pandemic and caused the most significant recession since World War II (Rahim et al., 2020). The European NextGenerationEU recovery package consists of EUR 750,000 million while the American equivalent consists of USD 4.5 billion, well above its European counterpart. Both stimulus plans emphasise their commitment to energy transitions and the opportunity to strengthen green objectives.

However, according to the OECD, only 21% of global stimulus plans have been allocated to ecological transition projects, with the remaining 79% of public funds going to projects that do not aim to solve climate problems. OECD / IEA (2021) which also emphasises that the current support for fossil fuels exceeds that for clean energy, hampering the efforts of the Paris summit.

The World Health Organisation (WHO) estimates that seven million people die each year from air pollution; however, the political and social ambitions following COVID-19 do not seem to work within the context of sustainability. argued that investors do not anticipate that the consequences of climate change will affect them since, in the short term, they affect geographies far away. This ensures that financial systems will fail in their responsibility in the face of climate change and that the inertia of financial markets will mean that in the absence of legislation, economic systems will not be able to redirect private capital away from fossil fuels. COVID-19 magnified this trend.

Nevertheless, several scientific papers have confirmed that during COVID-19, ESG investments outperformed traditional investments (Broadstock, Chan, and Wang, 2021; Rameli and Wagner, 2020), validating research that has argued that ESG investments protect investors from economic and financial crises (Albuquerque et al., 2020; Bouslah et al., 2018; Ding et al., 2020; Lins et al., 2017).

Due to the ambiguous signals that the markets and investors are sending about sustainable investments, this study wanted to understand whether the shareholders of the leading energy companies in Europe and the USA consider sustainability in their in-vestment decisions. Also, whether the COVID-19 pandemic, an unexpected, unpredictable, and non-repeatable historical event, changed their investment patterns towards sustainability, as it is known that uncertain contexts make the human being more irrational (Coşkun 2022).

This study analysed how high-volume positive, neutral, and negative sustainability news fluctuated company share prices. The research focused on the short-term market reactions that were associated with sustainability news, using the event study methodology. The event study methodology is a statistical methodology that is used to measure the impact of specific events on the value of companies: in this case, high-volume sustainability news. Shareholder reactions reflect how valuable sustainability news is in terms of their investment decisions.

We gathered several event studies analysing the tone of high-volume news (i.e., negative, neutral, and positive news) and the type of energy (renewable, fossil fuel or nuclear) to compare the market reactions in the USA and Europe during the periods before and during COVID-19.

Our goal was to understand whether or not sustainability narrative has similar effects on investors in both markets and whether the pandemic has changed the way investors invest.

To achieve this, we analysed all global and digital high-volume news on sustainability from 2017 to 2020, using the GDELT news database as a source of information.

The energy sector was chosen because it is the most strategic and central to the economy during the ecological transition towards decarbonisation. However, fossil fuels remain the primary energy source, representing almost 70% of European energy production (European Environmental Agency, 2020) and 80% of American energy production (Capuano, 2018).

Europe and US were chosen as the markets for our analysis because they rank first when analysing the historically cumulative CO2 emissions from fossil fuels (OurWorldinData, 2022)

Today, when analysing CO2 emissions per territory, we skip the historical responsibility of countries such as Europe and the US. Yet, in the context of climate justice, they are responsible for global cumulative CO2 emissions representing 17% and 24%, respectively (OurWorldinData, 2022). However, the European Union has a more ambitious plan regarding decarbonization the economy that the US (OurWorldinData2, 2022) and also, Europe moves more ESG investments than US, 41,6% and 33% respectively (Alliance, Global Sustainable Investment, 2020). So, analysing these two economies will show if stricter regulation means more compromised investors.

The use of news as a source of information has empirically demonstrated that the media is correlated with variabilities in stock market prices (Barber et al., 2009; Da, Engelberg and Gao, 2009; Oberlechner and Hocking, 2004; Tetlock, 2007).

This research contributes to the existing literature with a detailed sustainability narrative analysis of the energy shareholders of the two territories that have historically generated the most CO2.

By analysing two time periods (before and during the pandemic) and the three possible tones of the news (negative, neutral, and positive), we managed to reach a high level of understanding of the behaviour of the energy shareholders in the face of sustainability news. We identified incentives for greenwashing, distrust in renewable energies and behavioural changes during the pandemic.

Secondly, an analysis of 295,093 high-volume news items and 2,134 event studies assured statistical robustness.

To the best of our knowledge, studies have yet to be published investigating the effects on the stock market's capitalisation of sustainability news in such an exhaustive way. Previous studies have analysed the impact of sustainability or ESG news exclusively in some media, with more restricted concepts or hand-collected news (Krüger, 2015), making their results much less robust.

Finally, this information could be relevant to managers and boards of directors for designing and implementing effective ESG policies. Additionally, knowledge of the impacts of sustainability narrative could help legislators to develop incentives for shareholders that push for efficient ecological transitions.

The remainder of this article is structured as follows. First, we discuss related work. Then, we present the materials and methods that were used in our study, followed by the results section and, ultimately, the discussion and conclusions section.

12.2. Related work

Since the 1970s, the scientific community has searched for connections between CSR and corporate financial performance (CFP). However, early scientific studies considered investments in CSR as mere expenses that impoverished investors (Friedman, 1970; Clotfelter, 1985; Navarro, 1988). Today, investments in ESG keep growing and numerous investigations have correlated CSR and ESG with higher returns (Alshehhi et al., 2018; Consolandi et al ., 2009; Lu and Taylor, 2016; Munir et al., 2019; Yin et al., 2019) and lower risks of market fluctuations (Ahsan and Qureshi, 2021; Aouadi and Marsat, 2016; Flammer, 2013). At the same time, other studies have found no benefits for investors from CSR and have even identified adverse reactions (Curran and Moran, 2007; Cheng, Hong and Shue, 2013; Jensen, 2002; Krueger, 2015; Masulis and Reza, 2015; Oberndorfer, 2013).

So, there is no current scientific consensus that investments in sustainability and CSR produce a better financial performance. The authors of Capelle-Blanchard and Petit (2019) attributed this to the facts that the samples that were analysed were tiny and selected by hand and that not all of the available information was considered. The authors of Renneboog (2008) attributed it to the fact that investors only think about economic benefits, separating the rest of the variables from their decision-making. The authors of Xi et al. (2019) and Munir et al. (2019) argued that the lack of a consensus among researchers could be due to the wide range of metrics that have been used to measure financial performance and the broad range of CSR concepts.

However, there is a consensus that investors penalise companies more for irresponsible behaviour (Capelle-Blanchard and Petit, 2019; Krüger, 2015). A clear example is the Volkswagen case and its scam surrounding the reporting of its vehicles' emissions, which cost the company USD 33 billion (Hotten, 2015). This relationship has also been noted in disasters, such as the BP oil spill in the Gulf of Mexico (2010) and the nuclear accident at the Fukushima plant of the Tokyo Electric Power Company in Japan (2011). Shareholder overreactions to negative news has also been well researched by scientists (Lee, Hutton, and Shu, 2015; Miller, 2006; Olsen, 1998; Shiller, 2019; Shleifer and Vishny, 1997; Tetlock, 2007).

Numerous studies looking at CSR and CFP have focused on CSR reporting (Alshehhi et al., 2018; Charlo et al., 2027; Consolandi et al ., 2009; Eccles, Ioannov and Serafin, 2014; Lu and Taylor, 2016; Munir et al., 2019; Yin et al., 2019) or the inclusion or exclusion of listed companies in sustainable indexes (Cheung, 2011; Consolandi et al., 2009; Curran and Moran, 2017; Oberndorfer et al., 2013). However, these results could be biased. In CSR reporting, the companies themselves present the information and highlight their good actions (Krüger, 2015; Byunn and Oh, 2018), while the problem with sustainable indexes is that existing evidence for ratings varies significantly for the same company between agencies (Chatterjee et al., 2016).

In this research, we selected high-volume sustainability news as a source of information since the media plays a crucial role in the ESG dialogue and is associated with fluctuations in stock markets (Tetlock, 2007). Furthermore, more and more scientific research has empirically demonstrated that ESG news directly impacts stock markets (Capelle-Blanchard and Petit, 2019; Jacobs et al., 2010; Klassen and McLaughlin, 1996; Serafin and Yoon, 2021). Especially negative news (Barroso, Canela and Tort-Martorell, 2022; Flammer, 2013; Krüger, 2015).

The scientific literature has also analysed how the COVID-19 pandemic has influenced the stock market returns of ESG factors. Again, there is no apparent unanimity among the studies on whether a higher ESG index could prevent the potential losses that are associated with COVID-19.

On the one hand, some studies have proved that companies that bet on environ-mental and governance factors financially outperform those with lower ESG indices (Engelhardt et al., 2021; Garel and Petit-Romec, 2021; Gregory, 2022; Huang et al., 2020; Rubbaniy et al., 2021). However, on the other hand, others have argued that having a higher ESG index did not prevent financial losses during COVID-19 (Demers et al., 2021; Folger-Laronde et al., 2020; Huang et al ., 2021; Loof, 2021). Lastly, some studies have found that investors preferred to make low ESG investments during the pandemic (Demers et al., 2021; Ferrari and Natoli, 2020) as they did not immunise stocks.

The COVID-19 pandemic also hit the electricity market as electricity consumption fell to record levels due to the cessation of economic activities and lockdowns (Kanda and Kivimaa, 2020). Boldeanu, Clemnete-Almendros and Tache (2022) analysed European electricity companies and their stock price responses to COVID-19. They confirmed that COVID-19 had negative impacts on the whole industry, especially renewable energy.

This study analysed the leading energy companies in Europe and the USA. The energy sector was chosen because it is the most strategic and central to the economy during the current ecological transitions towards decarbonisation. However, fossil fuels remain the primary energy source, representing almost 70% of European energy pro-duction (European Environment Agency 2020) and 80% of American energy production (Capuano, 2018). Furthermore, while investments in renewable energy continue to grow and companies claim to be increasingly sustainable, greenhouse gases continue to rise (Elmalt, Igan and Kirki, 2021).

12.3. Materials and Methods

12.3.1. Materials

The sample for this study contained all high-volume news that was digitally published worldwide that mentioned the leading European or USA companies in the energy sector and a combination of keywords related to sustainability, as displayed in Table 1; for example, “Acea SP” + “gas” + “nitrogen oxides”.

The analysis period was from January 2017 to December 2020.

The databases that we used were the following:

- The European and USA companies in Thomson Reuters' top 100 global energy leaders (2019);
- GDELT (Global Database of Events, Language and Tone);
- Yahoo Finance.

Table 21. Data

Europe Companies*	USA companies*	Energy	Sustainability Keywords
Acea Sp	Anadarko	Gas	Nitrogen
AkerSolutions	Marathon oil corp	Fossil Fuels	Phosphorus
CairnIndia	Avangrid	Renewables	Carbon dioxide
DCC	Chevron corp	Nuclear	CO2
EON SE	CMS Energy	Coal	Methane
EDF	ConocoPhillips	Solar	Ozone
Enagas	ExxonMobil	Hydro	Pollution
Engie	Covia Holding	Wind	Waste
Eni	First Solar	Biomass	Plastic
Gruppa Lotos	Halliburton Comp	Geothermal	Footprint
Hellenic Petroleum	Hess Corp	Marine	Aerosol
Hera	Marathon Oil Corp	Tidal	Global warming
Motor Oil Hellas	Ni Source	Petrochemical	Emissions
National Grid	Occidental Petroelum Corp	Petrol	Greenhouse gas
Neste Oyj	Philips 66	Petroleum	Air quality
Lukoil	Schlumberger	Ethanol	Sea level
OMV AG	Sempra Energy		Climate change
Orsted	Sun Power		Extreme weather
Pennon Group			Natural resources
Petrofac			Biodiversity
PKN ORLEN			Toxic
Repsol			Extinction
Rosneft			Nitrogen cycle
Royal Dutch Shell			Ocean acidification
Rubis			Land use
RWE			Fresh water
Saipem			Depletion
Saras			Chemical Pollution
Siemens Gamesa			Overexploitation
Snam			Sustainability
Tecnicas Reunidas			Ecosystem
Tullow Oil			
Tupras			
Vallourec			
Vestas			
Enel			

To carry out the event study on the high-volume sustainability news sample, we first collected the following key information from the news: the date of publication; volume intensity (the combination

of the number of times a news story was read and its media coverage); the tone of the news (positive, negative, or neutral).

We obtained this information from the open-source news database GDELT package (GDELT Global Knowledge Graph (GKG) Version 2.0). For the tone of news, GDELT uses 51 data dictionaries, including the following popular dictionaries that have been high-lighted in the literature: "Harvard IV-4 Psychosocial Dictionary" "Harvard IV-4 Psychosocial Dictionary" (Stone et al., 1966), the "WordNet-Affect dictionary" (Strapparava et al., 2004; Valitutti and Strapparava, 2004), the "Loughran and McDonald Sentiment Word Lists dictionary" (Loughran and McDonald, 2016; Loughran and McDonald, 2011).

The next step was to filter out the high-volume news, i.e., the news with a high-intensity volume. Therefore, to be part of the analysis sample, the intensity volume had to pass a filter of two standard deviations from the mean of all news, which represented 2.5% and 5% of the total sample. In this way, we guaranteed that we were analysing the tail of the distribution and only the news with the highest reach.

The date of publication of this high-volume news indicated the events that were analysed in this study, which had a total number of 295,093.

The next step was to group the high-volume news into the following categories: energy and sustainability keywords (for example, "petrochemical" + "footprint") (Table 1); market (i.e., USA or Europe); period (i.e., before or during COVID-19); tone (i.e., positive, negative, or neutral).

The number of event studies that were gathered was 2,134.

Following the method in Bartholdy, Olson, and Peare (2007), event study with less than 50 events was eliminated from the analysis to guarantee an acceptable sample size and the robustness of the statistical results.

12.3.2. Methods

To measure the economic impacts of the high-volume news, we followed the methodology of Brown and Warner (1985) for our event study.

We studied the cumulative abnormal average returns (CAAR). The CAAR aggregates and cumulates the abnormal returns (AR) of all stocks n to find the average abnormal return at each time t. AR is calculated by deducting the returns that would have happened if the studied event had not occurred (expected returns) from the actual returns of the stocks. While the actual returns can be empirically observed, the expected returns need to be estimated. For that, expected returns models must be calculated.

According to MacKinlay (1997), to determine the lead of events to analyse the CAAR, the following characteristics should be considered.

1. Event date: Day of publication of the high-volume news. If several news describes the similar content within a 15-day window, the news with the highest volume intensity have been used as the event date.
2. Event window: In this case, [–7, 7] days. This window was wide to collect all of the information that was emitted by different media;
3. Estimation window: In this case, we used a 100-day pre-period. For the calculation of the expected returns, the event study methodology used the actual returns of the estimation window;
4. Expected return model: The model we used for the CAAR was the market model (mm), which has been widely accepted by the scientific literature and is the most commonly used.

   The market model (mm) looks at the actual returns of a baseline reference market and tracks the correlations between company stocks and the baseline. Equations (1) and (2) were used to specify the model. The abnormal return on a particular day ARit within the event window describes the difference between the actual stock return Rit on day t and the expected return, which is estimated based on two facts: the average relationship between the company stocks and the reference market (expressed by the α and β parameters) and the actual returns of the reference market Rmt.

   $$R_{it} = \alpha_i + \beta_i \cdot R_{mt} + \varepsilon_{it}, \quad (1) \quad \text{then,} \quad AR_{it} = R_{it} - (\alpha_i + \beta_i \cdot R_{mt}). \quad (2)$$

   Then, to calculate the [−7, +7] event window, we used the following equations. The cumulative abnormal returns (CARit) value refers to the sum of abnormal returns (ARit) over a given period of time, i.e., the [−7, +7] event window:

   $$CAR_{it} = \sum_{t=t1}^{t2} AR_i. \quad (3)$$

   The average abnormal returns (AARt) value aggregates the abnormal returns ARit for all n stocks to find the average abnormal return at each time t:

   $$AAR_t = \frac{1}{n} \sum_{i=1}^{n} AR_{it}. \quad (4)$$

   The cumulative average abnormal returns (CAARt) value, as illustrated in Equation (5), adds the average abnormal daily returns for the intervals within the event window:].

   $$CAAR_t = \sum_{t=t1}^{t2} AAR_t. \quad (5)$$

   The hypotheses of this study were analysed using a parametric test, i.e., the skewness-adjusted t-test (Hall, 1992) As documented in Fama (1965), Press (1967), Kon (1984), Gray and French (1990) and Aparicio and Estrada (2001), stock returns are not normally distributed and tend to be skewed. The authors of Pindick (1983), French, Schwert and Stambaugh (1987) and Campbell and Hentschel (1992) suggested that this is because news increases the volatility of stocks, which magnifies their

returns (especially negative news). Over 50 years ago, the authors of Fama (1970) pointed out that the way investors interpret the information around them affects market efficiency.

In the case of this investigation, the returns were skewed as we performed event studies that were segmented by tone: the negative and neutral news items were negatively skewed, and the positive items were positively skewed.

The authors of Lyon, Barber, and Tsai (1999), Banik and Golan Kibria (2011) and Cojbasic and Loncar (2011) found that the skewness-adjusted t-test that was introduced by Hall (1992) performed as well as equivalent non-parametric tests, as long as the sample size was not small.

Recalling the (unbiased) cross-sectional sample variance as:

$$\sigma(CAAR_t) = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(CAR_{it} - CAAR_t)^2}. \quad (6)$$

Then, the skewness estimation that focused on averaged abnormal returns was specified by:

$$t_{skew} = \sqrt{n}(S + \frac{1}{3}\hat{\gamma}S^2 + \frac{1}{6n}\hat{\gamma}), \quad (7)$$

$$\hat{\gamma} = \frac{\sum_{i=1}^{n}(CAR_{it} - CAAR_t)}{n\sigma(CAAR_t)^3}. \quad \text{where} \quad (8),$$

$$S = \frac{CAAR_t}{\sigma(CAAR_t)}. \quad (9)$$

Where $\hat{\gamma}$ is the estimate of the coefficient of skewness and $\sqrt{n}S$ is the conventional t-statistics.

To conclude whether deviations from the CAAR were statistically significant, we used the skewness-adjusted t-test. We defined the results as follows:

The abnormal returns could not be distinguished from zero:

Hypothesis H0 (H0): CAAR = zero

The abnormal returns could be distinguished from zero:

Hypothesis H1 (H1): CAAR ≠ zero

We decided to reject H0 when tskew > tcritical or the p-value < 0.05. This meant that the value was statistically significantly different from zero with a significance level of 5%.

This also meant that when tskew was greater than 1.96 or less than −1.96, we rejected that result, unless the result was not statistically different from zero.

12.4. Results

In this section, we discuss our results.

Figures 14 and 15 show the number of high-volume news items that were analysed. The distribution of all analysed news is represented in Figure 1 and the distribution of all statistically significant news

is shown in Figure 15. In order to compare the periods, the annual average number of news items from 2017 to 2019 was calculated.

Figure 14. The total number of analysed high-volume news items.

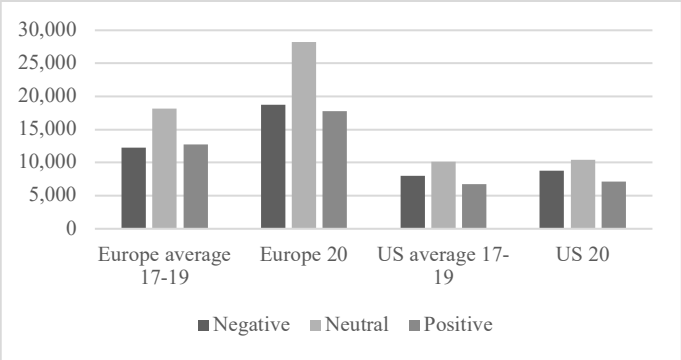
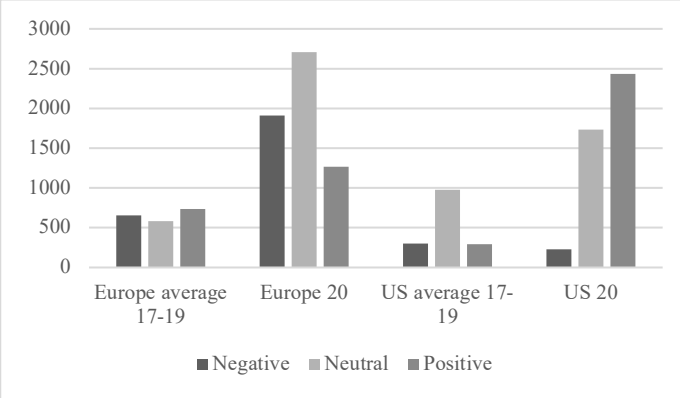


Figure 15. The total number of statistically significant high-volume news items.



In Figure 14, it can be observed that high-volume news about sustainability was more abundant in Europe than in the USA, both before and during COVID-19, but it was especially evident during the pandemic period.

However, as shown in Figure 15, most of the analysed high-volume news items did not have statistically significant impacts on stock markets, representing just 10% of the total news.

However, we should note that during the pandemic period, the high-volume news had more influence, especially the negative and neutral news items in Europe and the positive and neutral news items in the USA.

We concluded that there were few viral sustainability news items that impacted stock markets. However, investors reacted more to them during the pandemic than in previous periods. In addition, Europe had a more negative bias, accentuating the negative and neutral news. While in the USA, we found the opposite, as there were more positive and neutral news items.

Tables 22 and 23 show the aggregation of the results from all significant event studies by territory (i.e., Europe and USA), tone of the high-volume news (i.e., negative, neutral, or positive) and temporal period (i.e., before or during COVID-19).

Table 22. The aggregated results of significant news items from Europe, according to tone and temporal period.

		Europe 17-19					Europe 20				
	Event window	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies
Negative	(-7, +7)	-2,0519*	-0,0134	0,0215	124	16	-1,8186	-0,0231	0,0229	78	16
Neutral	(-7, +7)	-0,7651	-0,0036	0,0270	158	11	-0,8114	-0,0117	0,0229	94	26
Positive	(-7, +7)	-1,4902	-0,0077	0,0145	122	18	1,3613	0,0185	0,0235	103	9

*Statistically significant

Table 23. The aggregated results of significant news items from USA, according to tone and temporal period.

		US 17-19					US 20				
	Event window	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies
Negative	(-7, +7)	-1,7805	-0,0120	0,0307	72	9	2,6884*	0,0337	0,0103	57	5
Neutral	(-7, +7)	-1,8503	-0,0116	0,0236	93	30	2,4595*	0,0244	0,0202	58	6
Positive	(-7, +7)	0,8552	0,0057	0,0276	68	9	2,6913*	0,0220	0,0152	67	21

*Statistically significant

These tables show the aggregated results of the skewness-adjusted t-test, the CAAR value, the p-value, the average number of high-volume news items analysed by each event study and the number of event studies used in each aggregation.

In Table 22, which visualises the data from Europe, it can be seen that the only statistically significant event studies were those that were analysed as being negatively toned news during the pre-pandemic period.

It also should be highlighted that except for positive news items during the COVID-19 period, the other period and tones had negative skewness-adjusted t-test results, even though they were not statistically significant. Therefore, it could be concluded that Europe, in aggregate terms, tended not to react to sustainability news, even though the market showed a negative trend.

In the USA, however, the results were very different. We found statistically significant positive reactions during the pandemic period for news of all tones.

However, in the pre-COVID-19 period, we did not find any statistically significant results. Nevertheless, the sign of the skewness-adjusted t-test was worth noting, i.e., negative for negative and neutral news and positive for positive news, which followed the classic pattern found by previous research (Flammer, 2013; Krüger, 2015; Tetlock, 2007).

The results from the USA were striking as all news during the pandemic, regardless of the tone, caused a rise in stock market prices, which did not follow any previous patterns found in the existing literature.

By comparing the two markets, we could conclude that Europe was much more hostile towards high-volume sustainability news than the USA. Figures 14 and 15 show that Europe had more news about sustainability than the USA, which was predominantly negative or neutral. Therefore, a possible explanation for the data observed in Table 22 could be that the European media was more incisive towards sustainability and could negatively influence the markets.

Nevertheless, the positivity of the USA stock market towards sustainability news was very surprising. The fact that the event studies always found optimistic reactions, even when the news was negative, could indicate that sustainability news became less severe or that there were investment opportunities within the context of negative news about COVID-19. However, it should be noted that negative news items during the pandemic were the least frequent in the USA.

Tables 24–29 show the aggregated results of the statistically significant event studies as in Tables 22 and 23, but according to type of energy.

Table 24. The aggregated results of significant negative news items from Europe, according to energy type and temporal period.

Negative news		Europe 17-19					Europe 20				
Energy	Event window	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies
Fossil fuels	(-7, +7)	-0,9859	-0,0071	0,0152	79	5	-0,6155	-0,0084	0,0241	84	11
Renewables	(-7, +7)	-1,5884	-0,0106	0,0297	118	10	-2,3864*	-0,0285	0,0241	61	5
Nuclear	(-7, +7)	-2,8774*	-0,0164	0,0044	217	1					

*Statistically significant

Table 25. The aggregated significant results of negative news items from USA, according to energy type and temporal period.

Negative news		US 17-19					US 20				
Energy	Event window	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies
Fossil fuels	(-7, +7)						2,4702*	0,0333	0,0168	55	1
Renewables	(-7, +7)	-1,8551	-0,0124	0,0290	75	9	2,8060*	0,0359	0,0074	56	4
Nuclear	(-7, +7)										

*Statistically significant

By analysing the results from the significant negative news items, the negative skewness-adjusted t-test results from Europe, which were in line with the previous literature, showed price drops in stock markets after negative news. However, surprisingly, the USA showed the opposite results during the pandemic.

Before the pandemic, the only negative news items in Europe that presented statistical significance were those dealing with nuclear energy, while during the pandemic, significant news items were those related to renewable energy. News items about fossil fuel energy did not show significant results, so it could be concluded that the markets did not react to negative news about fossil fuels. Nevertheless, we did not find any significant reactions in the USA before the pandemic. However, during COVID-19, negative news about fossil fuels and renewable energy, against all odds, obtained positive significance.

The results for significant neutral news items, as shown in Tables 26 and 27, behaved similarly to those for negative news items, showing negative skewness-adjusted t-test results with the exception of news items from the USA during the pandemic period, which produced positive results, as with the negative news items.

Table 26. The aggregated significant results of neutral news items in Europe, according to energy type and temporal period.

Neutral news		Europe 17-19					Europe 20				
Energy	Event window	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies
Fossil fuels	(-7, +7)	-1,1570	-0,0043	0,0275	186	4	0,4404	0,0007	0,0215	108	13
Renewables	(-7, +7)	-0,7207	-0,0041	0,0295	160	7	-1,3907	-0,0191	0,0207	81	12
Nuclear	(-7, +7)						-2,5805*	-0,0183	0,0111	118	1

*Statistically significant

Table 27. The aggregated significant results of neutral news items from USA, according to energy type and temporal period.

Neutral news		US 17-19					US 20				
Energy	Event window	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies
Fossil fuels	(-7, +7)	-1,5651	-0,0108	0,0221	94	8					
Renewables	(-7, +7)	-2,1028*	-0,0124	0,0187	89	20	2,4595*	0,0244	0,0202	58	6
Nuclear	(-7, +7)	-2,1598*	-0,0115	0,0331	119	2					

*Statistically significant

However, on this occasion, we did not find any items with statistical significance from pre-pandemic Europe and during the pandemic, only news items about nuclear energy were significant.

In the USA, on the other hand, before COVID-19, we found significant negative reactions to news about renewable and nuclear energy. In contrast, during the pandemic, positive reactions returned in the case of renewable energy.

Finally, by analysing the significant results from positive news items, as shown in Tables 28 and 29, it was observed that the American market was much more optimistic than the European market, especially during the pandemic, presenting statistically significant results to news items about all types of energy. In Europe, however, we found negative reactions to news about nuclear and renewable energy during the pre-pandemic period, which were statistically significant.

Table 28. The aggregated significant results of positive news items from Europe, according to energy type and temporal period.

Positive news		Europe 17-19					Europe 20				
Energy	Event window	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies
Fossil fuels	(-7, +7)	0,2429	0,0036	0,0144	140	7	1,3970	0,0180	0,0110	97	5
Renewables	(-7, +7)	-1,6568	-0,0093	0,0143	100	7	1,0451	0,0164	0,0355	116	4
Nuclear	(-7, +7)	-2,9818*	-0,0179	0,0084	138	4					

*Statistically significant

Table 29. The aggregated significant results of positive news items from USA, according to energy type and temporal period.

Positive news		US 17-19					US 20				
Energy	Event window	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies	Average of Skewness Corrected T	Average of CAAR Value	Average of p_val	Average of number of news	Number of event studies
Fossil fuels	(-7, +7)	2,1960*	0,0108	0,0303	106	1	2,5184*	0,0245	0,0159	71	6
Renewables	(-7, +7)	0,8023	0,0059	0,0270	63	7	2,7432*	0,0218	0,0144	64	14
Nuclear	(-7, +7)	2,9479*	0,0175	0,0043	75	1	3,2057*	0,0246	0,0023	54	1

*Statistically significant

Europe's negative reactions to positive news items about nuclear and renewable energy could be because the investors of the companies in our sample are strongly linked to fossil fuels and see these alternative energy types as competition.

After analysing the reactions of the American and European markets to statistically significant sustainability news, it could be concluded that both markets were highly different. On the one hand, the American market was much more optimistic, particularly during the pandemic, perhaps because the sustainability news did not seem as threatening compared to COVID-19 news.

On the other, the European stock market was more negative, showing declines in prices even in the face of positive news items about nuclear and renewable energy.

12.5. Discussion

After analysing the reactions of the American and European markets to significant sustainability news before and during the pandemic, it could be concluded that both markets were highly different, especially during COVID-19, when shareholders faced uncertainty.

The results showed that American and European energy shareholders had different reactions to the sustainability narrative. The American market changed during the pan- demic to become much more optimistic. In contrast, the European stock market continued to be pessimistic, showing declines in prices even in the face of positive news items about nuclear and renewable energy.

This negative bias in Europe could have resulted from the mass media. Figures 1 and 2 showed that Europe published more sustainability news, predominantly negative and neutral items. This constant media coverage could have encouraged investor pessimism, which was also accentuated during the pandemic. In the USA, as sustainability news was less frequent and was not negatively biased (rather, the opposite), the market reacted contrastingly.

These results could suggest two opposite things: the European narrative was more demanding for renewable energy than the American narrative or, alternatively, European shareholders penalised renewable energy in favour of fossil fuels, which American share- holders did not do to the same extent. Nevertheless, both markets agreed that nuclear power was still on investors' agendas and that fossil fuels were less penalised by investors for negative or neutral news than other types of energy.

12.6. Conclusions

The author of Horcade et al. (2021) argued that investors do not anticipate the consequences of climate change since they will only occur in the future and far away from the West. Therefore, without legislation, investors will not change their way of investing simply out of conscience. Even so, the authors of Broadstock, Chan, and Wang (2021) and Rameli and Wagner (2020), stated that sustainable investment funds outperformed traditional investments during the pandemic.

This research aimed to analyse the reactions of energy company shareholders to high-volume sustainability news before and during the COVID-19 pandemic.

Our goal was to understand whether the sustainability narrative had comparable impacts on shareholders in both markets and whether the pandemic changed the way shareholders invest.

Understanding the shareholder's narrative on sustainability in periods of stability and uncertainty allows us to better sense their biases and cultural differences.

Observing the results of this research, it was noticeable that shareholders did not penalise fossil energy companies for negative news as they did with other sectors. Fur- thermore, the pandemic changed how investors acted, and it did so oppositely in the two analysed territories.

Suppose we want to move towards an effective ecological transition. In that case, legislators must change, through laws, the incentives of shareholders so that it is not more profitable to invest in fossil fuels than in more efficient energy sources. Investors prioritise their benefits over sustainability. Only through change in legislation can shareholders' narrative and profit optimisation strategies be directed towards pure ecological awareness.

The results of this research could be relevant to companies' boards to better communi- cate their sustainability commitments. Additionally, for legislators, knowledge about the impacts of sustainability narrative on shareholders could make it possible to legislate new incentives and align them with the desired ecological transition goals.

Future research should perform regression studies to explain share prices through such means as, for example, using news volume intensity. That way, we could identify specific news items that impact stock markets and analyse their characteristics.

This research had some limitations. First, the analysed period, the year 2021, when the pandemic was still ongoing, was omitted. Future research could update the results and even add the year 2022 to investigate the effects of the Ukraine Invasion and the energy crisis.

Second, regarding the event study methodology:

1. The CAAR values could reflect more than just the result of the sustainability news (such as other events impacting these companies).
2. The event window could be challenged because long windows suffer from the con- founding effects of other events, but shorter windows might not identify the real repercussions of media coverage.
3. The data dictionaries could have missed some keywords that might have created a more accurate narrative perspective.

13. Thesis 'Conclusions

The main objective of this doctoral thesis was to verify if sustainability is a decisive investment factor for investors and if it generates positive returns.

This dissertation was divided into four chapters, analysing the previous literature in the first chapter through a bibliometric study and supplemented with expert analysis that explored which income statement accounts affected the sustainability measures.

Thanks to this first chapter, we discovered that 70% of companies implementing sustainability measures have a positive economic impact on their operating or financial results.

After analysing the first chapter, the research focused on empirically verifying that sustainability affects companies' financial results.

In chapters two and three, we analyse all the global sustainability news from the leading European and American energy companies through the event study methodology.

Moreover, finally, in chapter four, we compare the European markets with the United States of America before and during the COVID-19 pandemic.

Our goal was to understand whether the sustainability narrative had comparable impacts on investors in both markets and whether the pandemic changed how investors invest.

The choice of energy companies as a sample of analysis is because they are the most prominent industries that generate CO2.

Europe and US were chosen as the markets for our analysis because they rank first when analysing the historically cumulative CO2 emissions from fossil fuels (OurWorldinData, 2022)

Today, when analysing CO2 emissions per territory, we skip the historical responsibility of countries such as Europe and the US. Yet, in the context of climate justice, they are responsible for global cumulative CO2 emissions representing 17% and 24%, respectively (OurWorldinData, 2022). However, the European Union has a more ambitious plan regarding decarbonization the economy that the US (OurWorldinData[2], 2022) and also, Europe moves more ESG investments than US, 41,6% and 33% respectively (Alliance, Global Sustainable Investment, 2020). So, analysing these two economies would show if stricter regulation meant more compromised investors.

In addition, this research use the news as s data source because the media serve as intermediaries providing information between companies and investors and can shape investors' expectations (Tetlock, 2014).

The main conclusion of this doctoral thesis found that the sustainability narrative significantly impacts shareholder value; however, this narrative's interpretation has no consensus. The sustainability news about these companies moves the stock market upwards for some investors, while others do the contrary. These results are observed by comparing CAAR and AV. The results found

by these chapters are crucial for regulators to push forward an effective ecological transition. It should be legislated so that a common investors' narrative discourages highly polluting investments.

The first chapter analysed the economic impact of being sustainable at a corporate level. We studied the 200 most cited articles about 'Corporate Sustainability Performance'. Analysing these articles, we discovered the research trends and the most frequent economic reactions to sustainability. Thus, combining a bibliographical analysis with expert analysis, this chapter offered a better picture of how sustainability affects companies from an economic impact point of view.

The analysis has been made from a bibliographic search in the Scopus database with the subject term being 'Corporate Sustainability Performance', and the 200 most cited articles had been downloaded (May 2018). We processed the data to perform two analyses, a bibliometric study, and an expert analysis.

The most outstanding findings of the expert analysis are the confirmation of a positive economic reaction in companies that apply sustainability measures in their work. For example, we saw that 70% of the companies that introduce sustainability measures have a positive economic impact, affecting 55% of the time their financial and 45% of their operative results.

In the second and third chapters, we analysed high-volume news publicly available at GDELT from January 2017 to December 2019, mentioning a combination of terms (Table 1) that includes: the sample companies, type of energy generation, environmental consequences, and the news' tone. Then, using the event study methodology, we studied how investors value sustainability news and companies' impact on getting good or bad press. It is remarkable the magnitude of the study. We identified 486,932 news events and conducted 8,558 event studies about CAAR and AV. The number of news articles analysed, and event studies conducted is much higher than any previous research, allowing robust results. In addition, to further guarantee the robustness of the study, results were only considered significant with a consensus of more than three out of five expected return models.

We analysed CAARs and AVs. However, due to multiple news events and the conflicting interests of the energy companies of the sample, mainly fossil fuel producers, the positive and negative CAAR could cancel each other. Consequently, a volatility study was conducted, which answered this potential problem by studying absolute values.

The main contribution of this investigation to the existing scientific literature is the confirmation that sustainability events got viral, creating a narrative that impacts shareholder value significantly. Nevertheless, the ratio of significant events is much higher in terms of AV than CAAR, showing no shareholder consensus about the narrative.

After analysing the CAARs and AVs, we could draw several conclusions. The main one was that negative and neutral news was the most abundant and influenced the stock market downside, showing a clear negative bias. Furthermore, this negative bias was observed for all types of energy. The results

also highlighted that the news on renewables was the most numerous and those with the most significant event studies; however, in the study of the CAARs, we observed how the results on positive news were offset, indicating a non-consensus of investors, and the AV analysis supported that fact. Ultimately, we identified positive news about fossil fuels impacting the market more than positive renewable energy news showing empirical evidence for the greenwashing business case.

The fourth paper concludes the thesis by comparing the two analysed territories, Europe, and the United States of America, analysing the CAAR, again with the event study methodology, and comparing the pre-Covid19 periods and the COVID-19 pandemic period. Our goal was to understand whether or not the sustainability narrative has similar effects on shareholder behaviour in both markets and whether the pandemic changed the way investors invest.

We gathered 2,134 event studies to compare the periods before and during COVID-19. In addition, we analysed all global and digital news on sustainability from 2017 to 2020 using the GDELT news database as a source of information, which contains 295,093 high-volume news.

The results showed notable differences between the American and European market reactions.

The American market changed during the pandemic to become much more optimistic. In contrast, the European stock market continued to be pessimistic, showing prices declined despite positive news items about nuclear and renewable energy.

This negative bias in Europe could have resulted from the mass media. As a result, Europe published more sustainability news, predominantly negative and neutral items. This constant media coverage could have encouraged investor pessimism, which was also accentuated during the pandemic. While in the USA, as sustainability news was less frequent and was not negatively biased (instead, the opposite), the market reacted contrastingly.

These results could suggest two opposite things: the European narrative was more demanding for renewable energy than the American narrative. Alternatively, European investors penalised renewable energy in favour of fossil fuels, which American investors did not to the same extent. Nevertheless, both markets agreed that nuclear power was still on investors' agenda and that fossil fuels were less penalised by investors for negative or neutral news than other types of energy.

When comparing the contributions of this research with the critical and previous scientific literature, we corroborate the negativity theory bias (Tierney and Baumeister, 2019; Corns, 2018)—particularly in finance, confirming that negative news has more impact on the stock markets than positive ones, as previous authors found (Olsen, 1998; Shleifer & Vishny, 1997; Tetlock, 2007). In addition, however, this study contributes to the existing literature founding that neutral news, in the case of sustainability news, behaves as negative news; this fact has, as far as the author knows, never discussing before.

Compared with previous authors that also analysed sustainability news (Flammer, 2013; Aouadi and Marsat, 2016; Oberndorfer et al., 2013; Krüger, 2015; Blanchard and Petit, 2019), the present research verifies with a much larger sample that negative sustainability news causes negative abnormal returns on the stock market after the publication of negative news and positive after positive news but in much less extend. Nonetheless, this study analysed energy corporations exclusively, finding apparent differences between energies and giving valuable information on the investors' preferences. Furthermore, as Elmalt, Igan and Kirki (2021), this thesis found a contradiction between the upwards trend with sustainability and no change in the business. While investments in renewable energy continue to grow and companies claim to be increasingly sustainable, investors rewarded fossil fuels more than renewable energies. This fact goes hand in hand with the increase in CO2 emissions found by the authors mentioned above.

Lately, it surprises the positive American reaction to negative news during COVID-19 regarding CAARs. Contrary to the previous literature mentioned above, it responded positively. Further analysed are needed to understand why.

In summary, investors are not aligned with the sustainability narrative in the energy production sector. This can impact the sustainability investments, a vital tool for a sustainable transition. Sustainable Finance strategy is at the top of the agenda for all the 196 countries that signed off at the COP 21 in Paris Agreement, especially the192 ones that were confirmed at the last COP26 in 2021. The objective was to mobilise the public and private finance sectors to support securing global net-zero emissions and protecting communities and habitats. During the last decade, companies, investors, and lenders have become increasingly concerned about their business decisions on environmental, social and governance (ESG) matters. This spotlight has emphasised how investment decisions are vital to mitigate climate change, comply with current and future regulations, and limit reputational damage.

In July 2021 EU Commission adopted a package of measures to move money towards financing the transition to a sustainable economy. By enabling investors to re-orient investments towards more sustainable technologies and businesses, the UE wanted to achieve climate and environmental targets. Also, leveraging a European green bond standard (EUGBS), a voluntary standard to help scale up the environmental ambitions of the green bond market. In that sense, this research methodology could provide transparency on the sustainability narratives and validate the effect of specific tools like CO2 taxes and those mentioned above.

Future research lines should compare investors' reactions to the sustainability narrative in countries with different legislation regarding sustainability. For example, comparing countries like Sweden, where CO2 rates are very high, with countries with more lax legislation, it could be analysed whether fiscal disincentives help to change the shareholder's narrative regarding sustainability. Also, other

research should perform opposite studies, i.e., use regression to explain share prices through news volume intensity instead of using the event study methodology. That way, we could identify specific news items that impact stock markets and analyse their characteristics.

This research faced the classic limitation of the event study methodology: Primarily, the CAARs cannot exclusively be the consequence of the sustainability news. Subsequently, determining a precise estimation period is problematic; with long windows, while the confounding effect with other events can occur, there is a possibility of not catching the real media repercussion with shorter windows. The clustering effect between news can also happened (Kolari and Pynnoen, 2010). Moreover, the data sources could have omitted keywords to make the news search more accurate. So, it cannot be guaranteed the results being the same with a shorter or more extensive data dictionary or with another period analysed; further robustness test needs to be performed to prove it

Future directions of this study should focus exclusively on renewable energy companies to analyze if shareholders interested in renewables have a standard sustainability narrative and overreact to negative news. It would also be very enriching to the current literature to compare the reactions of the shareholders of the countries with current carbon taxes and those without to see if their narrative towards sustainability changes and makes them more demanding. Also, and in order to improve the methodology, future lines of research could analyse the evolution over time of investor reactions to sustainability news, which would provide a thermometer of the sustainability narrative and how it evolves, providing valuable information to companies and legislators of where the ecological transition of companies is advancing

And finally, another line of research could focus on the event study methodology using the results of this research to analyse which expected return model behaves more adequately and accept or reject the hypothesis that the market model behaves as good as the complex ones.

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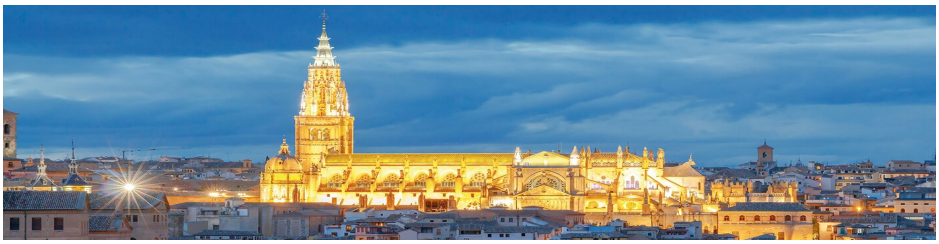
15. Annexes

15.1.A Congress Certificates

15.1.1. Communication Diploma



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Negócios e sociedade: sustentabilidade e transformação digital

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Diploma de Comunicación

TÍTULO

«BUSINESS CASE OF ADOPTING CORPORATE SUSTAINABILITY MEASURES: A MULTI-STUDY THROUGH A BIBLIOMETRIC RESEARCH AND LITERATURE REVIEW»

AUTOR/ES

Alberto Barroso Del Toro*
Xavier Tort
Miguel Angel Canela

* Presentador

ha sido presentada en el

XXI Congreso Internacional AECA (online)

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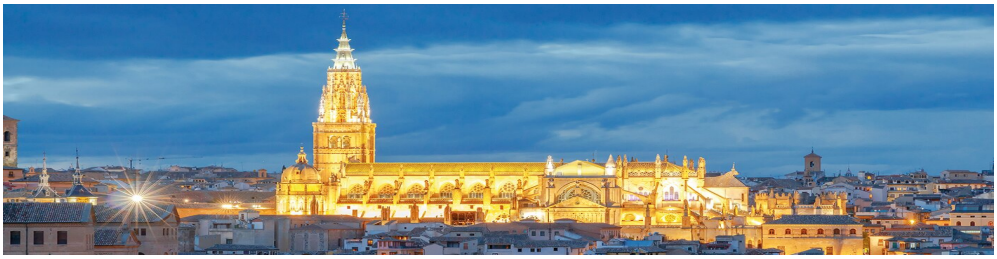
15.1.2. Attendance Diploma



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Business and society: sustainability and digital transformation

Negócios e sociedade: sustentabilidade e transformação digital

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Diploma de Asistencia

D. Alberto Barroso Del Toro

ha participado en el

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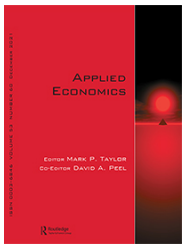
15.2.B Published papers

15.2.1. Second Chapter



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How shareholders react to sustainable narratives about leading European energy companies? An event study using sentiment data from the global database for events, language and tone (GDELT)

Alberto Barroso del Toro, Xavier Tort-Martorell & Miguel Angel Canela

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15.2.2. Third Chapter

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Article

The Sustainability Narrative: A Multi Study Using Event Studies to Analyse the American Energy Companies Shareholder's Reaction to Sustainability News

Alberto Barroso Del Toro, Laura Vivas Crisol and Xavier Tort-Martorell

Special Issue
The Effects of Green Finance and Promotion Policies on Green Energy Development and Environmental Management

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Prof. Dr. Chih-Chun Kung, Dr. Shih-Chih Chen, Dr. Chengcheng Fei, Dr. Tsung-Ju Lee and Dr. Tao Wu

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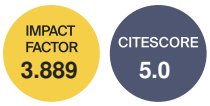
15.2.3. Fourth chapter



Article

Comparing the Impacts of Sustainability Narratives on American and European Energy Shareholders: A Multi-Event Study Analysing Reactions to News before and during COVID-19

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